DRAFT ADDENDUM 1
REMEDY EVALUATION REPORT FOR THE
KERR-McGEE CHEMICAL CORPORATION SUPERFUND SITE
TRONOX FACILITY SODA SPRINGS, IDAHO

March 1, 2009

Prepared by:

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March 2, 2009
Mr. Boyd Schvaneveldt
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P.O. Box 478
Soda Springs, Idaho 83276

RE: TRANSMITTAL: DRAFT ADDENDUM I REMEDY EVALUATION REPORT FOR THE KERR-McGEE CHEMICAL CORPORATION SUPERFUND SITE TRONOX FACILITY - SODA SPRINGS, IDAHO

Dear Boyd:

Please find transmitted the Draft Addendum 1 Remedy Evaluation Report for the Kerr-McGee Chemical Corporation Superfund site. As discussed in the final work plan, this report presents a review of the remedial actions that were completed at the site in 1997 and 2001. This evaluation fulfills the Task 3.2 deliverable requirements of the final Addendum 1 to the Statement of Work of Remedial Design/Remedial Action Consent Decree for the Kerr-McGee Superfund Site (Addendum 1) from EPA officially dated April 24, 2008. This document is transmitted as required by the one-month delivery schedule triggered by the acceptance of the final Addendum 1 work plan by EPA on February 2, 2009.

We appreciate the opportunity to work with you on this project. If you have any questions regarding this transmittal, please contact us.

Very truly yours,
Global Environmental Technologies, LLC

John S. Brown, P.G.
Principal/Owner

Attachments: Work Plan

xc: Matt Paque – Tronox Inc. – Hard Copy
John Hatmaker - Tronox Inc. – Hard Copy
Bill Ryan — EPA Region X – (4 hard copies)
Doug Tanner — IDEQ Pocatello –Hard Copy
Clyde Cody — IDEQ Boise - Hard Copy
Tom Mosko – CH2M HILL = Hard Copy

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1.0 INTRODUCTION

1.1 General

The following report provides an evaluation of the existing remedy for the Kerr-McGee Chemical Corporation Soda Springs, Idaho Superfund Site. The site is currently owned by Tronox. This remedy evaluation report presents the results of the analyses and tasks completed that were detailed in the Draft Final Addendum 1 Work Plan submitted on January 14, 2009. The work plan was conditionally approved with the EPA requested modifications to section 3.4 in the work plan approval on January 29, 2009. Changes to the final work plan were completed and transmitted to EPA on February 20, 2009.

The Kerr-McGee Chemical Corporation Soda Springs, Idaho site was placed on the National Priorities List on October 4, 1989. The effective date of the consent order to conduct a remedial investigation and feasibility study (RI/FS) was October 4, 1990. The remedial investigation required by the consent order was completed in 1995. The Record of Decision (ROD) was signed in September 1995 and amended in 2000. The feasibility study (FS) for the entire site was completed in 1996 and a supplemental feasibility study for the calcine capping was completed in 2000. The remedial actions were completed in two phases; the first phase completed in 1997 and the second phase completed in 2001.

1.2 Site Location

The Tronox site (formerly known as the Kerr-McGee Chemical Corporation site) is located in Caribou County, Idaho approximately 1.5 miles north of Soda Springs as shown in Figure 1-1. The Tronox site is on the east side of State Highway 34. The site is bordered by agricultural land on three sides (north, east and south) and by the Monsanto Chemical Company elemental phosphorus plant on the west (on the west side of the highway) as shown on Figures 1-1 and 1-2.

Figure 1-3 shows the location of the monitor wells sited near source areas investigated as part of the remedial investigation (RI), (Dames & Moore, 1995). The location of the landfill that was constructed as part of the remedial actions and the lined solvent extraction ponds are shown on Figure 1-3. Currently, the double lined 10-acre pond is the only remaining pond at the site.

1.3 Site Investigations

Site investigations that were performed as part of the RI/FS included:

- A preliminary geological reconnaissance to develop a conceptual hydrogeological model of the site;
- Core drilling activities at five locations across the site to characterize both geological and hydrogeological conditions;
- Borehole geophysical logging of coreholes, deep monitor well borings, existing monitor wells and off site monitor wells;
- Aquifer testing of ground water monitoring wells and coreholes to characterize the hydrogeology, which included packer tests, slug tests and both long-and short-term pumping tests;
- Ground water monitor well installation to evaluate both background and downgradient water quality data and hydrologic data at locations both on and off the site;
- Surface soil and source material sampling to evaluate chemical and physical properties, and to evaluate potentials for airborne particulate release from the site;
- Sampling of liquid sources to characterize the chemical quality of pond waters at the site;
- Sampling and physical analysis of soils collected from various pond berms and liner materials to evaluate the physical characteristics of the materials and to estimate potential seepage rates;
- Drilling and sampling of solid sources and overlying and underlying soils to characterize physical properties of the soils and sources for evaluation of the vadose zone;

- Installation and sampling of lysimeters to characterize the quality of leachate being generated in the vadose zone;
- Collection of twelve rounds of ground water samples from newly constructed on-and off-site wells to characterize ground water quality;
- Off-site sampling of springs and existing private wells to evaluate water quality and identify potential impacts, if any, to ground water at off-site locations;
- Air Pathway Modeling of stack and source emissions from the site, and analysis of impacts from emissions to soils and human health, and;
- Ground water modeling of the site and off-site locations.

Subsequent investigations were performed during the remedial design/remedial action (RD/RA) project phase. These investigations were performed to support the design and construction of the on-site landfill and the calcine cap, and to monitor the performance of the ground water following remedial measures specified in the ROD. These studies included:

- S-X and scrubber pond sediments investigations;
- Geotechnical evaluation of the S-X and scrubber pond sediments, calcine and native soils;
- Soils investigations in the area of the landfill, the soil borrow area, and at locations surrounding the calcine impoundment, and;
- On-going semiannual ground water and surface spring monitoring.

Locations of the investigated media for the RI/FS and locations of borings and sampled locations are presented on Figures 1-5, through 1-7.

1.4 Site History

Construction of the vanadium production plant facility was completed in the summer of 1963 and full operation began in March 1964. Operation of the vanadium plant continued until January 1999 when the plant was shut down. A number of waste impoundments generated during vanadium plant production are shown on Figures 1-3 and 1-4. The vanadium plant facility was demolished in 2002 and the site surface was covered and graded with limestone fines.

In 1997 and 1998, Kerr-McGee constructed a fertilizer production plant facility that was intended to process the calcine produced by the vanadium plant and to process material from the calcine impoundment on the east side of the plant facility. The plant operated intermittently until July 2000 when the plant ceased operation after it was determined by EPA that Kerr-McGee would be unable to reduce the calcine impoundment within a specified timeframe of 8 years shown in the Record of Decision (ROD). Calcine was dewatered in a centrifuge, stored in the building above the former MAP ponds and taken in a loader to the east calcine area until vanadium operations ceased. Some of the dewatered calcine was processed in the fertilizer plant. The calcine was capped in August 2001 and the fertilizer plant was demolished in 2002 and 2003.

The Tronox facility currently produces lithium-manganese oxide. Production of this material began in 1999. This material is used to produce rechargeable batteries. There are no liquid discharges from the current operations.

Site activities and a chronology of process changes are shown in Table 1-1. This table includes activities prior to and following implementation of the site remedies.

1.5 Summary of Baseline Risk Assessment

A Baseline Risk Assessment of the KMC LLC site was completed by SAIC for the EPA (1993) to evaluate potential impacts to human and ecological receptors from exposure to site-related contaminants in the absence of remedial action. The risk assessment was divided in two sections; one section addressed the potential impacts to human health and the other looked at potential impacts to ecological receptors. Additional sampling of the sediments in Finch Pond located approximately 4,000 feet to the south of the site was completed and this information was used to further investigate the potential impacts to ecological receptors.

Evaluations of human health risks were performed for three scenarios, including:

- The current industrial scenario;
- The future industrial scenario; and
- The future residential scenario.

The future residential scenario evaluated risks for receptors on both the northern and southern property boundaries of the site. For the current industrial scenario, lifetime excess cancer risks from exposure to combined radionuclides in the ferrophos ore were not much greater than background.

The future industrial scenario yielded similar results. Future exposures to radionuclides from on-site sources were not much higher than background. Ingestion of vanadium in the roaster reject area resulted in a hazard quotient of 1.7.

For the future residential scenario at a location to the south of the site, conservative estimates of risk were calculated based upon longer durations of exposure in comparison with the industrial scenarios. Five contaminants of concern (COC), their hazard quotients (HQ), and risk based concentrations (RBC) were identified for the future residential scenario. The COC, HQs, and RBC include:

- Manganese; HQ = 3, RBC = 0.18 mg/l;
- Molybdenum; HQ = 32, RBC = 0.18 mg/l;
- TBP; HQ = 3, RBC = 0.18 mg/l;
- TPH; HQ = 3, RBC = 0.73 mg/l; and
- Vanadium; HQ = 14, RBC = 0.26 mg/l.

Exposures to inorganic and organic chemicals in the ground water to the south of the site indicated a risk to human health; however, the shallow ground water was not likely to be used for drinking water purposes because municipal water from the town of Soda Springs is readily available.

Carcinogenic risks from uranium-238 and decay progeny in the soils were not much greater than the background risk. No significant risks or potential adverse health effects were indicated to the north of the facility.

Results of the ecological risk assessment suggested that substantial ecosystem risks from exposure to site related contaminants were not probable. This assessment concluded that there were no substantial ecosystem risks from chemical releases from the facility. This was confirmed by sediment sampling at Finch Pond. These results indicated that there were no substantial risks to ecological receptors by contacting or ingesting the sediments in this pond.

1.6 Exposure Pathways

The exposure pathways evaluated during the RI included:

- Contact/ingestion of ground water;
- Contact with roaster reject;
- Contact with areas of windblown calcine;
- Inhalation of material from the site;
- Contact/ingestion of surface water, and ;
- Contact with off-site soils.

All of the exposure pathways were investigated as part of the risk assessment discussed above. The exposure pathways of concern include:

- Contact/ingestion of ground water;
- Contact/ingestion of the roaster reject, and;
- Contact with the windblown calcine.

The other exposure pathways were shown to have no significant risk and no further action was taken to address these pathways. Remedial Action Objectives (RAO) were developed for the three pathways of concern.

1.7 Remedial Action Objectives (RAO)

The draft Human Health Risk Assessment indicated that the primary medium of concern was the ground water and the primary concern with ground water was ingestion. Therefore, the RAO for the site with respect to ground water included:

- Prevent the transport of COC to the ground water from facility sources that may result in COC concentrations in ground water exceeding RBC or MCL;
- Prevent ingestion by humans of ground water containing COC having concentrations exceeding RBC or MCL, and;
- Prevent transport of COC from ground water to surface water in concentrations that may result in exceedences of RBC or MCL in the receiving surface water body.

A secondary concern at the site was the roaster reject area. The RAO associated with this material was:

- Prevent the ingestion/direct contact with the roaster reject area material having vanadium concentrations in excess of 14,000 mg/kg.

Although the risk assessment concluded that there were no substantial ecosystem risks due to releases from the facility, there were localized areas that were impacted by the solid sources (saltation of the calcine). The risk assessment indicated that these areas may pose a risk to sensitive plants and field mice in the area. The RAO associated with the ecosystems include:

- Prevent the transport of COC from the solid sources to the ecosystem in amounts that exceed the 95 percent upper threshold limit (UTL) concentration in background soils.

1.8 Performance Expectations

Kerr-McGee was notified by EPA on October 31, 1995, that all the requirements of the Administrative Order on Consent had been fulfilled. Kerr-McGee and EPA entered into a Consent Decree on September 30, 1996, to complete the remedial actions described in the ROD. During 1997, many of the remedial actions listed in the ROD were completed to address liquid source elimination (LSE) and closure of the unlined pond facilities. A complete compilation of the Remedial Action Completion activities completed in 1997 is described in the Draft Remedial Action Completion Report Revision I (GET, 1999).

Performance expectations for the Kerr-McGee Soda Springs facility were defined in the Consent Decree, the ROD, and stated in the EPA SOW. Performance expectations defined are consistent with CERCLA, the NCP, and state and federal standards. Performance expectations include:

- Clean up standards, substantive requirements, criteria or limitations and ARAR specified in the ROD, Consent Decree and SOW;
- Clean up efforts of solid sources from the S-X pond and the scrubber pond as specified in the ROD; and,
- Performance standards which may be identified during the Remedial Design period of the project.

The performance standards for ground water are MCL, non-zero MCLG, State of Idaho standards, COC with cancer risk exceeding 10^{-6} (arsenic only), and non-cancer COC that exceed the RBC.

1.9 Summary of the Record of Decision

The Record of Decision (ROD) for the Kerr-McGee Chemical Superfund site was signed September 28, 1995. The remedial actions required by the 1995 ROD included:

- Elimination of uncontrolled liquid discharges from the facility to soil, surface or ground water;

- Excavation and reuse/recycling of buried calcine tailings within an 8-year period;

- Excavation and on-site disposal of S-X and scrubber pond solids in a lined and covered on-site landfill cell;

- Semi-annual ground water monitoring to determine the effectiveness of source control measures and a comprehensive evaluation of ground and surface water monitoring data;

- Establishment of Institutional Controls to curb ground water use for as long as the ground water exceeds the performance standards;

- Resource recovery/reuse of the roaster reject in the vanadium production facility, and;

- Excavation and on-site disposal of the windblown calcine.

During April 2000, EPA revised the original site clean up plan, and drafted the proposed change to the clean up plan that included capping the calcine in place. The public comment period for the proposed plan was from April 20 to May 22, 2000. The ROD amendment was signed on July 13, 2000. The ROD amendment specified capping the calcine tailing on the east side of the industrial facility in place. The roaster reject and off-specification fertilizer from the fertilizer plant were to be included in the material placed under the cap. The roaster reject was included because the vanadium plant was not operating. The off-spec fertilizer was included because there was no market for the material and additional material was needed to fill the area. All other requirements of the September 1995 ROD remained in effect.

The EPA ROD amendment addressed:

- Changes to the original cleanup plan;
- Completed clean up actions;
- Other available alternatives;
- Evaluation of the alternatives;
- Compliance with regulations;

- Reduction of toxicity, mobility and volume;
- Short-term effectiveness;
- Implementability;
- Cost;
- State and community acceptance;
- Proposed revision to the ROD.

The final remedy selection included capping of the calcine, roaster reject, and rejected (off-spec) fertilizer.

1.10 Summary of 5-Year Reviews

The five-year review by EPA is required by statute because the ROD was signed after October 17, 1986 and hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure. In September 2002, five years following the completion of the remedial action in 1997, EPA performed an inspection and completed the first 5-year review for the site. EPA concluded during September 2002 that "hazardous waste cleanup continues to be effective, and that people and the environment are protected as the cleanup continues". According to EPA, "Kerr-McGee Chemical Corporation is doing an excellent job managing the site, and the cleanup is moving forward. The results of groundwater monitoring show that contaminant levels are decreasing, and the contaminant plume has not increased in size" (EPA, 2002). EPA further concluded "Now that the contaminant sources are under control, natural processes, such as biodegradation and dilution, will gradually make the groundwater useable" (EPA, 2002). Ground and surface water data in 2002 indicated that ground water clean-up goals had been met for arsenic in all but one well (KM-8), clean-up goals had been met for tributyl phosphate in all but one well (KM-8), clean-up goals had been met for manganese in all but two wells (KM-3 and KM-8), and clean-up goals had been met for TPH in all wells except one well (KM-8). Vanadium and molybdenum remained dispersed in the ground water aquifer beyond the property boundaries in 2002.

EPA Region 10 conducted a second five-year review of the remedial actions implemented at the site from June 2007 through September 2007. The U.S. Army Corps of Engineers (USACE) provided support to EPA in the data analysis and evaluation of remedy protectiveness for the second five-year review. The USACE conducted the site inspection on behalf of EPA. A site inspection was conducted on July 25, 2007. The purpose of the second five year review inspection was to assess the protectiveness of the remedy, including the integrity of the caps, the condition of the monitoring wells and restrictive fencing. The second five year review found that the remedies were constructed in accordance with the requirements of the ROD, however a protectiveness determination of the remedy was not made because levels of COC in ground water and surface water remained above cleanup goals. COC trends, such as those noted in wells KM-3, KM-8, KM-6 and KM-16 following 2004 questioned the probability of achieving those goals in the foreseeable future. The second five year review identified the following actions to be taken for EPA to issue a protectiveness determination for the site.

- Evaluate the likelihood of the remedy achieving cleanup goals within a specifiable timeframe;
- Evaluate adequacy of current ground water monitoring network for identifying the offsite migration of COC;
- Assess whether current ground water and surface water performance standards are still adequately protective, and;
- Work with the laboratory providing analytical services to reduce the ground water detection and reporting limits to less than the current Maximum Contaminant Level (MCL) for arsenic (EPA, 2008).

The reduction of the detection limits for arsenic was completed in October 2007 through a change in the analytical method. This new method will be used for all future analytical work. A letter report documenting the change in the analytical method and an analysis including previous results was transmitted to EPA on March 26, 2008. Analyses indicated that the EPA Method 6020 ICP-MS method did not result in a substantially different outcome with respect to the arsenic MCL when compared with previous testing results.

1.11 Conceptual Site Model

A conceptual site model was prepared prior to the RI (Dames & Moore, 1991) as a requisite to developing the remedial action objectives and the general response actions for the site. The site model indicated the principal sources of potentially elevated concentrations of constituents in ground water occurred from direct seepage from the effluent ponds and past incidents of or spills (Dames & Moore, 1991). Precipitation, infiltration and leaching of piles and soils were occurring. It was believed that the primary potential pathway for migration and exposure was the ground water. This eventually was shown in the RI/FS to be the primary exposure pathway.

The early conceptual site model stated that spills were assumed to be important because prior pond containment failures had occurred over relatively short times (less than a day to about a week) (Dames & Moore, 1991). The failures initiated a slug of COC to ground water which moved relatively rapidly through the ground water system. The early conceptual site model stated the surficial soils were not considered to be a significant source of elevated concentrations or a primary exposure pathway, which was eventually demonstrated through risk assessment. Site spills were reported to have been minor (with the exception of the two pond containment failures). Precipitation falling on the site was contained within the solid source and pond areas, and surface water runoff was apparently nonexistent. Precipitation evaporated, infiltrated, or was contained within the S-X, scrubber, MAP, and calcine ponds. Ground water was assumed to discharge to surface water at downgradient locations based on prior sampling results.

The RI/FS did not expand on the conceptual site model. A conceptual site model was not presented in the RI/FS, although a simplistic conceptual site model was developed for the risk assessment performed by EPA (SAIC, 1993) and is presented on Figures 1-

8 and 1-9 (SAIC, 1993). The most important pathway remained ground water and the ground water impact to surface water, as demonstrated on Figure 1-10 (ROD, USEPA, 1995). Surface water does not leave the site, so the surface water pathway was no longer a consideration. Solid sources, including the calcine tailing, roaster reject and scrubber solids on or buried beneath the ground surface were noted to have potential impacts to ground water by forming leachate in the vadose zone. Chemical and physical properties of the underlying soils were shown to reduce the COC in the vadose zone. Paired lysimeter in the vadose zone confirmed this effect, demonstrating that the attenuating properties of the native soils were important in reducing the COC. Data from these lysimeters were considered in the model. However, no lysimeters were placed in the scrubber or S-X ponds or underlying soils at that time.

Vanadium plant closure actions and dismantling of the plant in 2002 represent the greatest changes at the site since the RI/FS and the ROD. No liquids are generated at the site and no waste products are exposed at the surface.

In order to assess the trends in ground water COC as presented in the MAROS evaluation (Appendix B) this report, the conceptual site model was refined and illustrated prior to performing the analysis. Figure 1-11 and 1-12 are depictions of the current CSM for the hydrogeologic setting and COC transport processes. The base map for these two figures is an aerial map of the site area oriented to the northeast and tilted to the northwest to provide a 3-dimensional perspective. The surface was cut away at a diagonal, from the northeast corner of the plant (east of the capped calcine tailings ponds) to the southwest corner of the Tronox property, crossing Highway 34 and ending at paired deep and shallow wells TW-11 and TW-12 on the adjacent Monsanto site. Site features such as the former ponds and plant area are labeled. The subsurface geology forms the third dimension in the diagrams and was constructed from geologic cross sections provided in the RI.

1.11.1 CSM for Hydrogeologic Setting

The subsurface geology shown in the CSM for the hydrogeologic setting was simplified from cross sections in the RI (Dames & Moore, 1995). The cross sections were originally interpreted from logs of borings for Monsanto wells TW-11 and TW-12 and Tronox wells and core holes KM-15, KM-18, KM-16, KM-8, PW-10, and CH-1. In the site model, the wells and core holes were placed at their intersections with the surface map and made to extend vertically to a projected depth of 300 feet. The wells were interconnected in what is typically referred to as a fence-diagram, where the surface between wells (fence section) changes direction depending on the spatial orientation of the section relative to the diagram. For example the section between Wells KM-15 and KM-16 is oriented southwest to northeast, whereas the section between KM-16 and KM-8 is oriented more south to north.

The thin, discontinuous layer of alluvium is shown on top where noted in borings. The five basalt flows and interflow zones are shown in their relative locations. In general, the basalt flows dip to the west and are offset by faults. Faults are projected from geologic features and seismic interpretations as shown on the cross sections. Water level elevation is interpreted from the cross section and is generalized; it does not show variations in ground water elevations.

The insert in Figure 1-11 shows the path of water moving in the broken, vesicular and scoriaceous materials at the tops and bottoms of flow beds, through interbedded sediments and through vertical joints in the dense basalt flows. Sources of water in the model are from infiltration from rainfall and snowmelt, pond seepage, and recharge from the aquifer. Water flow paths indicate horizontal flow with a vertical downward component induced by pumping wells at Monsanto. Faults are shown as zones of similar or slightly increased flow. The lower Salt Lake Formation is interpreted to be near wells KM-8 and KM-19 and does not interconnect with flow in the basalts.

1.11.2 CSM for COC Transport Processes

Figure 1-12 shows a conceptual site model for COC transport processes. The same diagram base is shown as used in the CSM for the hydrogeologic setting. Stippling patterns show where COC may be present in the vadose zone beneath former ponds and the main plant site as well as in ground water migrating downgradient from the site area. A slightly denser stippled pattern is shown beneath the former S-X pond, settling ponds, and plant area indicating areas with continued source leaching.

Contaminant flow paths are illustrated in two inserts in Figure 1-12. The first insert illustrates the main physical transport processes of advection, dispersion, and diffusion. The second insert shows reactions that affect the transport of COCs on a granular level including precipitation, adsorption, oxidation-reduction, ion exchange, bacterial degradation, complexation and chelation, colloidal transport, and decay.

2.0 HYDROGEOLOGY

2.1 Hydrogeologic Setting

The following discussion of the hydrogeologic setting is summarized from the RI. The site is located about 1.5 miles northeast of the City of Soda Springs, within the Bear River Basin, which is characterized by broad, flat valleys bordered by northwest trending mountain ranges. The valley where the site is situated is part of the Bear Lake Fault Graben Structure, a long narrow graben extending from Bear Lake (south of Soda Springs) to the Blackfoot Reservoir (13 miles north of the site). The facility is located near the center of the valley with the Chesterfield Range and the Soda Springs Hills to the west and the Aspen Range to the east. The facility is within the Blackfoot Lava Field which fills the valley between the mountain ranges and is characterized by irregular surface of numerous cliffs, scarps, collapse structures and fissures.

The shallow ground water system in the valley consists of ground water that occurs within the alluvium (limited areas), the basalt sequences and the basalt interflow zones, and the Salt Lake Formation. The basalts form the major aquifer for wells in the region with water occurring in fractures, joints, rubble zones, and inter-layered cinder beds. The Salt Lake Formation is considered a highly unpredictable source of water supply with variable yield. Recharge to the shallow system occurs through infiltration of precipitation, leakage from the Blackfoot Reservoir, and from ground water originating from the Meade Thrust Aquifer System (originating from the Aspen Range to the east of the site) and the Chesterfield Range Aquifer System (west of the site).

In general, ground water flows from the mountain ranges toward the center of the valley, then southwest toward the Bear River. Springs occur on both sides of the valley. Finch Spring, Upper and Lower Ledger Springs, and Big Spring are located south of the facility, at distances of 4,000 feet to about three miles to the south. Big Spring is the most distant spring, located south of the town of Soda Springs.

2.2 Site Hydrogeology

The following discussion of the site hydrogeology is summarized from the RI report. Site geology, to a depth of about 230 feet, consists of intermittent alluvial deposits, Quaternary basalts and interflow zones, and the Tertiary Salt Lake Formation. The alluvium refers to all of the unconsolidated surficial deposits that overlie bedrock, including alluvium, loess, and weathered basalt. The underlying basalt consists of five individual basalt flows that range from 20 to 80 feet thick. Interflow zones between the basalt flows are predominantly comprised of clay with lesser amounts of basalt, gravel, cinder, and organic materials. The basalts and interflow zones dip gently to the west. The underlying Salt Lake Formation consists of sandstones, conglomerates, and limestones.

Four north-trending faults transect the geology beneath the site. The faults are interpreted from seismic data and surficial features (northern trace of the Finch Spring Fault). The faults are typically downthrown to the west with small (less than 20 feet) displacements.

All the on-site and off-site wells that form the monitoring network were installed within the basalts sequences and interflow zones. Thirteen of the 18 wells are designated as shallow wells, completed with 10 feet of screen across the first occurrence of groundwater noted during drilling (total depths of 45 to 73 feet). Four wells are designated as intermediate-depth wells, completed with 20 feet of screen extending to total depths of 100 to 173 feet. One well is designated as a deep well, completed with 20 feet of screen extending to a total depth of 230 feet. The deep well was completed near the base of the basalt sequence. A production well, PW-10, located near the plant, was drilled to a total depth of 250 feet, which was interpreted to be within the basalt sequence (cross section F'-F" of the RI). The Salt Lake Formation was encountered in core hole CH-3 at a depth of 231 feet below surface.

Remedial investigations completed between 1991 and 1994 indicated that ground water beneath and downgradient from the Tronox site exists within the basalt sequences, the basalt interflow zones, and within limited areas of the alluvium. Ground water exists within the Tertiary Salt Lake Formation that underlies the basalt. Although ground water occurs in the Salt Lake Formation and within a limited area of the alluvium on-site, the basalts are considered the principal aquifer beneath the Tronox site.

The hydrogeologic properties of the basalts and interflow zones were characterized for the RI/FS, using:

- Geologic, geophysical, hydraulic head, hydraulic gradient, and hydraulic conductivity parameters from the installed wells;
- Hydraulic response data observed in the monitor wells, and;
- Observation and testing data from 14 on-site monitor wells, 4 off-site monitor wells and 5 on-site coreholes.

Table 2-1 was taken from the RI (Dames & Moore, 1995) and shows that the Salt Lake Formation has a hydraulic conductivity that is one to three orders of magnitude smaller than the hydraulic conductivity of the basalt aquifer. The basalt aquifer is the principle site aquifer that that lies unconformably above the Salt Lake Formation. Table 2-1 lists the results of hydraulic conductivity testing of the current monitoring well system in decreasing order, and identifies the locations, elevations and the completed depths and screened intervals for these wells.

2.2.1 The Salt Lake Formation

The Tertiary Salt Lake Formation is comprised of tuffaceous sandstones, conglomerates and limestones that yield small amounts of ground water for domestic and stock purposes, and are unpredictable as a water-supply source. The Salt Lake Formation is not considered part of the shallow ground water system. The Salt Lake Formation was cored on-site in corehole CH-3 from 231 to 250 feet (total depth of corehole CH-3) and was found to consist of fractured quartzite, sandstone, and clay with a packer test hydraulic conductivity of 0.77 ft/day. This is within, but at the low end of the range of packer-test hydraulic conductivities estimated for the deeper part of the overlying basalt sequence. No wells at the Tronox site were completed within the Salt Lake formation because the hydraulic conductivity of the formation is small, and the ground water quality monitored at the most downgradient location on the site in the deepest portion of the basalt aquifer (well KM-19) meets the risk-based concentration (RBC) for each site COC. Therefore, the vertical extent of the ground water quality impacted by site COC was defined in the RI to be within the overlying basalt aquifer.

2.2.2 Alluvium

Seismic refraction studies performed as part of the RI indicated that alluvium is thickest and extends to the greatest depth on the eastern side of the plant facility. Based on geologic data from well KM-2, an area of saturated alluvium overlies the basalt in the eastern part of the Tronox facility at well KM-2 where the elevation of the basalt/alluvium contact falls below the elevation of the water table. The area of saturated alluvium appears to be limited near the east side of the facility, extending a short distance to the north and south of the capped calcine tailings. The alluvium has not been noted to contain ground water at other locations on the Tronox site.

2.2.3 Basalt Aquifer

The basalts and interflow zones of the mid-Pleistocene Blackfoot Lava Field comprise the principal aquifer beneath the Tronox site. All on-site Tronox monitor wells, with the exception of monitor well KM-2, are screened exclusively within these basalts and interflow zones as shown in Table 2-1. The Monsanto production wells are screened within the basalt aquifer to the top of the Tertiary Salt Lake formation.

The basalt sequence at the Tronox site, described in the Final Remedial Investigation Report (Dames and Moore, 1995) is comprised of five identifiable basalt flows (Basalts Nos. Qb_1 through Qb_5) and associated interflow zones (Interflow Zones Nos. I_1 through I_4). Two younger basalts (Qb_{5a} and Qb_{5b}) and associated interflows were identified to the south and west of the site and are believed to have occurred as post-faulting flows. These basalts and interflow zones are believed to be stratigraphically similar to basalt flows identified at the Monsanto Site by Golder (1985 and 1992a).

However, the hydrogeologic characteristics of the basalt flows between the two sites appear to be different. Magnitudes of hydraulic conductivities of the basalt flows and interflow zones at the Tronox site are relatively similar as shown in Table 2-1, whereas basalts and interflow units at the Monsanto site are indicated to differ substantially. Testing during the RI indicated magnitude of hydraulic conductivities observed at the KMCC site (0.01 to 340 ft/day) is less than the magnitude range reported for the Monsanto site for basalts and interflow zones (1 to 10,000 ft/day). Local water level elevation and water quality differences exist between adjacent shallow, intermediate-depth and deep wells at Monsanto. Water quality and aquifer test data for Tronox indicate that the entire thickness of saturated basalt is in relatively good vertical hydraulic connection over the area of the Tronox site.

Faults are considered to represent zones of increased transmissivity at the Tronox site. The fractured bedrock and interconnected nature of the fractures within the basalt aquifer beneath the Tronox site allow for notable mixing of site COC within the shallow and intermediate depths of the aquifer. This is particularly notable at nested sites KM-15 and KM-18 to the west (downgradient) of the Finch Spring Fault. Ground water flow directions from the Tronox site are normal to (across) structural geologic features such as mapped fractures and the Finch Spring Fault. Faults were interpreted to be barriers to flow at the Monsanto site. Based on interpreted ground water contours for the Monsanto site, direction of ground water flow is interpreted to be in the same approximate bearing as the trend mapped faulted features to the south of the Monsanto production wells. Therefore, faults at the Monsanto represent more of an obstacle to flow by offsetting more permeable against less permeable zones in the aquifer.

2.3.3.1 Hydraulic Conductivities of the Basalt Aquifer

Primary permeability of unbroken basalt is small. Most ground water in basalt is transmitted along secondary features such as joints or fractures. Vertical columnar joints are a common feature observed in basalt exposed to the south and southwest of the site along the trace of the Finch Spring Fault. The presence of intensely fractured or vesicular zones, rubble zones, and/or cinder zones can greatly increase the ability of basalt to transmit water. Interflow zones are comprised of subaerial deposited materials, including clays, cinderaceous deposits, alluvial sands and gravels, organic debris and weathered and broken basalt. Variations in the ability of interflow zones to transmit water result from changes in the character and thickness of these materials.

Observed hydraulic conductivities estimated from the slug, specific capacity, and pumping tests conducted in the shallow, intermediate-depth, and deep wells shown in Table 2-1 include the following:

- Basalts ranged from 8 to 340 ft/day;
- Interflow zones ranged from 90 to more than 200 ft/day.
- Basalts and interflow zones together ranged from 2 to more than 100 ft/day.
- Basalt No. Qb_5 (shallow basalt represented by shallow well screened zones including KM-2, KM-5, KM-6, KM-7, KM-8, KM-9, KM-13, KM-15 and KM-16) ranged from about 9 to 340 ft/day.
- Basalt No. Qb_3 (Deeper basalt screened in wells KM-10, KM-11, KM-12, and KM-18) ranged from 8 to almost 100 ft/day.
- Hydraulic conductivities estimated for monitor well KM-19 screened in Basalt No. Qb_2 and Interflow Zone No. I_1 ranged from about 15 to almost 70 ft/day.

Distribution of the hydraulic conductivity across the site is shown on Figure 2-1. Generalizations about hydraulic conductivities observed within the basalt aquifer at the Tronox site shown in Table 2-1 include the following (Dames & Moore, 1995):

- The hydraulic conductivities of interflow zones are not significantly greater than those of the basalt flows;
- Hydraulic conductivities of the shallower basalts (Basalt No. Qb_5) are generally greater but not significantly greater than those of the deeper basalts (Basalt No. Qb_3);
- A horizontal layer of significantly smaller hydraulic conductivity which could greatly limit or prevent vertical movement of ground water was not identified;
- A continuous horizontal layer of significantly larger hydraulic conductivity along which horizontal ground water flow could be localized was not identified;
- Hydraulic conductivities in the shallow wells on the east side of the plant (KM-1, KM-2, KM-3, and KM-4) range from 90 to 270 ft/day and appear to be greater than hydraulic conductivities in shallow wells on the west side of the plant (KM-5, KM-8, KM-9, and KM-13), which range from 9 to 48 ft/day.

2.4 Site Water Levels and Site Precipitation

Figure 2-2 presents annual rainfall totals for Soda Springs, Idaho between 1990 and 2007, obtained from Tigert Airport in Soda Springs. Annual totals peaked at about 17.5 inches in 1994 and 1997. Annual precipitation rates declined after 1997 to about 11.5 inches in 2001. Annual precipitation rates increased on average between 2001 and 2005, to just over 15 inches annual average, then decreased dramatically in 2007 to less than 10 inches.

Site ground water level changes over time correlate with variation in the annual average precipitation, rates, although general rises in site water levels lag the precipitation by about three years, based on the observation of the low annual average in 2001 and recovery in water levels in site wells after 2004. Overall, water levels dropped on average 5 to 8 feet between 1997 and October 2001, and then remained at lowered levels in the fall through 2004, as indicated on Figure 2-3. Water levels recovered several feet between 2004 and 2006, and then declined between 2006 and 2008. Seasonal water levels are typically higher by about 2 to 3 feet in the spring when compared with the fall water levels.

2.5 Ground Water Level Elevations

Figure 2-3 presents the ground water level changes in the monitoring wells. Changes in depths to ground water in wells demonstrate cyclic periods of high and low ground water levels in response to seasonal changes in recharge. Longer term cycles are apparent with water levels responding to periods of drought lasting several years. Ground water levels dropped 5 to 8 feet between 1997 and 2001 and have recovered several feet between 2004 and 2007 towards the range of levels observed in 1997. Ground water pumping at Monsanto has resulted in apparent long-term water level declines, primarily on the west side of the site.

2.6 Ground Water Flow Direction

Ground water flows in response to hydraulic gradients from areas of higher hydraulic head to areas of lower hydraulic head at rates that are proportional to hydraulic conductivity and hydraulic gradient and inversely proportional to effective porosity of the aquifer. Ground water can flow vertically through aquifers or between aquifers in response to vertical hydraulic gradients and horizontally within aquifers in response to horizontal gradients. Ground water in the Shallow Aquifer System generally flows southward from the topographically higher Blackfoot Reservoir (about 12 miles north of the Tronox facility) to seeps and springs along the topographically lower Bear River.

The direction and rate of ground water flow beneath the site is influenced locally by heterogeneities in hydraulic conductivities within the basalts, with higher conductivities found in the basalts on the east side of the site. The flow direction is also affected by ground water pumping from Monsanto, located west of the property. Instead of flowing south as the regional aquifer does, ground water flow in the aquifer beneath the west side of the site is to the west toward Monsanto's production wells. A vertical downward gradient is noted on the west side in off-site wells KM-15 and KM-18. This downward gradient is the result of the influence of pumping the lower part of the basalt aquifer at Monsanto's production wells. Outside the area of influence of the Monsanto wells, flow is to the southwest and south. Ground water levels beneath the east side of the facility have a more southwesterly flow component, consistent with regional flow patterns. Faults do not appear to be barriers to flow, but may locally increase both vertical and horizontal hydraulic conductivities.

Horizontal hydraulic gradients and ground water flow directions within the shallow basalt units at the site are indicated by water level elevations measured during May 2008 and are contoured on Figure 2-4. Site gradient averaged about 0.02 ft/ft in 2008.

Ground water potentiometric gradient changes over time for the site were evaluated to assess the impacts to water levels and flow directions, and to evaluate whether changes in flow directions resulted in changes in COC concentrations. Ground water elevation contours were evaluated for the following periods:

- November 1992 (during site and pond operation with production well operating) shown on Figure 2-5;
- October 2001 shown on Figure 2-6 (following LSE and plant closure), and;
- May 2008 shown on Figure 2-4.

Comparisons of water levels elevations for the three periods indicate similar gradients over time with little change with respect to flow directions across the site and little change with respect to vertical gradients between the shallow and intermediate-depth wells. The calcine cap construction in 2001 may have resulted in subtle changes in the water level gradients when comparing water level elevations in wells KM-2, KM-3 and KM-4. However, these changes do not affect the overall gradient beneath the site over time. Therefore, when comparing the COC concentration and gradient maps from the

RI with recent COC concentration and gradient maps, it does not appear that changes in COC concentrations were affected by the limited site gradient changes or changes in flow paths over time.

2.7 Distribution of COC

COC concentration decay trends are documented through temporal changes observed in the existing monitoring well network used in conjunction with the Evergreen, Monsanto, and spring surface water data. Of the six COC, both tributyl phosphate (TBP) and total petroleum hydrocarbons (TPH) are present in very small concentrations in the southwest corner of the site. Arsenic, manganese, molybdenum and vanadium exceed RBC in several of the on-site wells but only molybdenum and vanadium are above the RBCs in off-site wells. Molybdenum is readily soluble in water and is more mobile than vanadium in ground water. A pulse of molybdenum reached Finch Spring by the time monitoring began in 1991. May 2008 COC concentrations and historic concentrations are presented in Table 2-2.

2.7.1 Manganese Distribution in the Basalt Aquifer

Manganese concentrations decreased with time in nearly all wells following LSE and remedial actions completed in 1997. Manganese concentrations decreased more rapidly than vanadium and molybdenum concentrations following LSE. However, manganese currently exceeds the RBC in two of the Tronox monitor wells (KM-3 and KM_8). Well KM-3 ground water indicates an increasing manganese trend since 2001. The ground water manganese concentration in monitor well KM-8 is seasonal. Ground water concentrations decreased substantially in KM-8 between 1997 and 2004, but currently concentrations of manganese are increasing and remain an order of magnitude greater than the RBC.

Manganese concentrations in ground water for May 2007 are shown on Figure 2-7 and extend from the west side of the former scrubber pond in KM-3 in a westerly direction towards KM-6 and KM-8. The largest manganese concentrations appear centered about the south end of the covered S-X pond basin, with a trend towards the south toward well KM-16. Manganese concentrations decreased with time in nearly all of the monitoring wells relatively quickly following LSE.

May 2007 manganese concentrations in ground water for on-site Tronox wells ranged from less than detection in well KM-19 to 5,000 micrograms per liter (ug/l) in well KM-8. The RBC for manganese (180 ug/l) was exceeded in two POC wells, KM-3 (560 ug/l) and KM-8 (5,000 ug/l). Manganese does not exceed the RBC to the south or west of the POC wells in either the Evergreen wells or in the Monsanto wells utilized in this evaluation. Manganese was reported to be less than the detection limit to 2.6 ug/l at Upper and Lower Ledger Spring. Manganese was also less than the detection limit Finch and Big Springs during May 2007. The current monitor well network defines the off-site migration of manganese. Downgradient wells at Evergreen and Monsanto confirm this finding.

2.7.2 Molybdenum Distribution in the Basalt Aquifer

Molybdenum exceeds the RBC (180 ug/l) in all of the on-site wells with the exception of wells KM-5, KM-9 and KM-19. The molybdenum RBC is exceeded at all Tronox well locations to the south of the industrial facility, and at Finch Spring and Big Spring. Molybdenum was less than the detection limit in Upper and Lower Ledger Spring during May 2007. However, molybdenum was reported at the RBC (180 ug/l) in October 2008 at Finch Spring. Figure 2-8 illustrates that concentrations of molybdenum are elevated in areas centered to the south end of the former S-X pond and about the perimeter of the covered scrubber pond. This area of elevated molybdenum in the ground water follows the zone of larger hydraulic conductivity to the southwest towards wells KM-15 and KM-18, Evergreen well EV-1, and as far west as Monsanto well TW-12. Monsanto wells TW-33 and TW-38 located to the west of the Tronox facility show molybdenum concentrations in the range of 50 ug/l. This concentration is slightly greater than the average molybdenum concentrations being removed from the Monsanto production wells PW-1 through PW-4.

2.7.3 Vanadium Distribution in the Basalt Aquifer

Vanadium is detected at concentrations above the RBC (260 ug/l) in all of the on-site wells with the exceptions of intermediate well KM-11 and deep well KM-19. Vanadium concentrations in May 2007 ranged between 10 ug/l in KM-11, to 18,000 ug/l in well KM-8. During May 2007, the vanadium concentration in Finch Spring was 58 ug/l and 2.5 ug/l in Big Spring. Vanadium was less than the detection limit of 10 ug/l in Upper and Lower Ledger Springs.

Figure 2-9 illustrates the distribution of vanadium concentration in ground water beneath and downgradient of the site. Larger vanadium concentrations are consistently identified near the south end of the reclaimed S-X pond and west of the southern half of the calcine cap and the covered scrubber pond. Vanadium concentrations in off-site Tronox monitor wells located southwest of the site exceed the vanadium RBC, as well as Monsanto well TW-12 and Evergreen well EV-1. Based on the concentration in well TW-33 at Monsanto, vanadium persists on the eastern portion of the Monsanto site in as ground water impacted from the Tronox site is drawn in the direction towards the production wells and discharged.

To the south of the industrial facility boundary, ground water from monitor well KM-17 (18 ug/l) remains substantially less than the RBC for vanadium, and defines the eastern boundary of vanadium detection in the ground water. Elevated vanadium concentrations extend southwesterly along a zone of larger hydraulic conductivity from the industrial facility boundary towards the Evergreen facility, defining the southeastern position of vanadium in ground water in an area close to Finch Spring. The largest concentrations of vanadium are projected to be found between KM-15 and the Evergreen facility. The areas of greatest vanadium concentration in ground water are projected to be found between highway 34 and Finch Spring. Monsanto wells TW-56 and to the south, the Lewis well, show vanadium at or near the detection limit.

2.8 Ground Water Geochemistry

Ground water at the site is classified as a calcium-magnesium bicarbonate type. Major ion concentrations in wells background wells KM-1 and KM-10 are similar to the off-site upgradient wells (Dames & Moore, 1995). Plots of the major ions for the site wells indicate mixing of background type waters beneath the site with pond seepage and contributions from leachate produced in the vadose zone. Water flowing onto the site is relatively high in calcium and low in sodium and potassium. Waters are compositionally high in bicarbonate. Waters mixed beneath the site increase significantly in sodium, potassium, sulfate and chloride.

2.8.1 pH

The pH range in ground water historically indicated neutral to slightly alkaline conditions in the past. Between 1999 and 2001, field pH was found to be lower in many of the wells near the reclaimed S-X pond including samples from wells KM-6, KM-7, KM-8, KM-12, KM-19, and near the reclaimed scrubber pond (KM-2, KM-3, KM-4, and KM-11). The lower ground water pH (range of 6.1 to 6.9) likely had some affect on concentration trends for metals during the 1999 through 2001 period, potentially resulting in metals concentration increases during this period (GET, 2008). Current site distribution of pH is shown on Figure 2-10. During the October 2008 sampling event, pH indicated slightly lower values south of the covered S-X pond area toward well KM-16, with the lowest pH occurring in the vicinity of well KM-8. The pH is slightly more alkaline (~7.3) in the former scrubber pond area.

2.8.2 Dissolved Oxygen and Oxidation Reduction Potential (ORP)

Dissolved oxygen (DO) and redox potential (ORP) provide indicators of anaerobic conditions within the aquifer. In general, DO measurements of less than 1 part per million (ppm) suggest that anaerobic conditions may be present in the ground water. Anaerobic microbial processes will occur at strongly negative redox potentials. The

ORP of ground water suggests the relative oxidizing or reducing nature of the ground water system. Redox potential field data result form interactions between chemical species present in the ground water and microbial byproducts.

Dissolved oxygen and ORP obtained in the field during October 2008 are shown on Figures 2-11 and 2-12 respectively. Dissolved oxygen concentrations in the aquifer are reduced across the site in a southerly direction, as shown on Figure 2-11, with more than 7 mg/l in ground water from background well KM-1. The remaining wells on the site and off site with the exception of KM-5 (2.4 mg/l) and KM-7 (1.13 mg/l) are less than 1 mg/l.

ORP measurements indicate negative values at KM-3 and KM-9. Generally, ORP is smaller on the east side of the site near cap and downgradient of the cap.

2.8.3 Ammonia

Ammonia is a nutrient required for microbial growth and activity and provides a nitrogen source for bacteria. Biodegradation activity within the aquifer can be controlled by the concentrations of ammonia within the ground water.

Ammonia concentrations in shallow wells and off-site locations for October 2008 are shown on Figure 2-13. Concentrations range from near detection in well KM-1 to more than 690 mg/l in KM-8. Ammonia was predominant in the S-X raffinate stream, however the S-X raffinate was also routed to the scrubber pond. Ammonia concentrations shown on Figure 2-13 indicate elevated in shallow well KM-3 (150 mg/l).

2.8.4 Dissolved Manganese

Manganese concentrations are decreasing with time in nearly all of the wells. During October 2008 dissolved manganese concentrations in Tronox monitor wells were obtained. Results are shown on Figure 2-14. Dissolved manganese concentrations in ground water for on-site wells range from 1.3 ug/l in well KM-19 to 1,900 ug/l in well KM-8. Well KM-3 (670 ug/l) indicates increasing concentrations since 2001.

2.8.5 Dissolved Iron

Dissolved iron concentrations were obtained from the monitor wells in October 2008. During the RI, iron was detected at small concentrations in all of the pond waters, with maximum concentrations identified at the now out-of-service boiler blowdown pond (1.63 mg/l). Comparisons of iron concentrations in unfiltered (total) and filtered (dissolved) samples collected during the RI indicated that iron concentrations were large in unfiltered samples, but were generally much smaller or less than detection in corresponding filtered samples. Therefore, it appeared during the RI that iron concentrations were increased by increases in turbidity.

Distribution of dissolved iron across the site is shown on Figure 2-15. This figure indicates that dissolved iron concentrations are larger in the central portion of the industrial site south of the covered boiler blowdown pond and smaller immediately downgradient (east) of the calcine cap. The largest dissolved iron concentrations are found to the west of the S-X pond. Intermediate depth wells typically have slightly larger dissolved iron concentrations.

2.8.6 Total Organic Carbon

Ground water samples for total organic carbon (TOC) were obtained in October 2008. Results indicate that TOC was less than detection in the background wells KM-1 and KM-10, wells KM-5, KM-6 and KM-13 and off site wells KM-15, KM-16 and KM-17. TOC concentrations were largest in KM-8 (4.4 mg/l) and KM-3 (1.6 mg/l). The remainder of the wells indicates TOC concentrations are less than 1 mg/l. The carbon source could be the No. 2 fuel oil used in the S-X process.

2.8.7 Silica

Ground water samples for silica were obtained in October 2008. Results indicate that silica concentrations range from 15 to 24 mg/l, with well KM-8 yielding results of 50 mg/l.

3.0 CURRENT REMEDY DESCRIPTION

A complete discussion of the remedial action completion activities is described in the Draft Remedial Action Completion Report Revision I (GET, 1999), and the Draft Remedial Action Completion Report for Calcine Capping, 2000 through 2001 (GET, 2003). Remedial Actions for the Tronox vanadium facility addressed the selected site remedy from the Record of Decision (ROD, September 1995) and subsequent amendment to the ROD (July 2000). The remedial action for the site included:

- Elimination of uncontrolled liquid discharges from the site;
- Landfilling solids from the scrubber and S-X ponds at an on-site landfill;
- In-place capping of the wind-blown calcine, roaster reject, reject fertilizer, and active calcine tailings during 2000 and 2001;
- Semi-annual ground water monitoring to determine the effectiveness of source control, and;
- Establishment of institutional controls in affected off-site areas to prevent ingestion of ground water for as long as the ground water exceeds the RBC.

3.1 Elimination of Uncontrolled Liquid Sources

Four (4) uncontrolled liquid sources (S-X Pond, scrubber pond, multiple calcine ponds and (3) Magnesium Ammonium Phosphate (MAP) Ponds) were identified during the Remedial Investigation. The Record of Decision (U.S. EPA, September 1995) called for the elimination of the uncontrolled liquid sources as soon as practicable. This work was completed between 1993 and 1997. The purpose of the liquid source elimination portion of the project was to eliminate the infiltration of 300 to 350 gallons per minute (gpm) of process water. These liquid discharges included solvent extraction raffinate, roaster scrubber water, process water used to sluice MAP to the MAP ponds and process water used to sluice the calcine to the calcine ponds.

The MAP ponds were eliminated in 1993 by installing filters to collect the solids for sale while the water was recycled in the vanadium plant. The MAP ponds were eliminated during the RI in 1993 and no investigations were completed in the MAP ponds area.

The solvent extraction raffinate stream was redirected to a series of lined ponds constructed in 1995 and 1997 (shown on Figures 1-2 and 1-3). After the dismantling of the vanadium plant, the two five-acre ponds were consolidated in 2004 to the 10-acre pond and the liners were removed. The 10-acre pond constructed in 1997 still exists on the site and contains about 20,000 cubic yards of S-X solids and salts.

Baghouses were installed on the roasters replacing the wet scrubbers, which eliminated the scrubber water stream. The scrubber pond was dewatered in 1997 and solids removed and impounded in the on-site landfill.

The calcine produced by the vanadium facility was handled by a mechanical de-watering system. The process water used to transport the calcine to the de-watering system was returned to the vanadium plant for reuse and the “de-watered calcine” was transported to the storage area by means of loaders.

3.2 On-Site Landfill Construction

The 1995 ROD required construction of a landfill to contain process sediments from the S-X and scrubber pond basins. The sediments remaining in the S-X and scrubber pond basins were excavated to native soil or to the calcine material beneath the S-X pond and placed in a lined on-site landfill, shown on Figure 1-3. The landfill construction was completed in 1997.

Approximately 13,000 cubic yards of material were removed from the two ponds and placed in the on-site landfill. The landfill was constructed with primary and secondary liners, leachate collection and an engineered geomembrane cap and soil cover. The cover was seeded to prevent erosion and the landfill footprint area was fenced to control access. Excess liquid contained by the waste when it was compacted in the landfill was removed through the leachate collection system. This liquid was pumped to the west 5-acre lined pond until 2004. The sump discharges a small volume at this time which is currently pumped to a lined concrete impoundment.

Following excavation of the sediments from the S-X and scrubber ponds, the pond basins were backfilled with clean native soil and contoured with a positive slope. The cover material was seeded to prevent erosion.

3.3 Calcine Capping

The 2000 ROD amendment (U.S. EPA, July 2000) required that calcine used as a feedstock for the fertilizer process, roaster reject and off-spec fertilizer be capped within the existing footprint of the calcine impoundment. The cap construction was completed in 2001. The roaster reject and off-spec fertilizer were compacted within the calcine area prior to capping. The calcine material was compacted and sloped and an engineered geomembrane cap was placed over the material. The engineered cap consisted of linear low-density polyethylene (LLDPE), overlying geocomposite, subsoil and topsoil. After the topsoil was placed and smoothed, the entire area was seeded to control erosion. The entire area was fenced to control access.

3.4 Institutional Controls

The institutional controls for the site were reviewed in conjunction with the requirements found in the Consent Decree and to the requirements found in the following guidance document; EPA 540-F-00-005 OSWER 9355.0-74FS-P dated September 2000.

Institutional controls required in the 1995 ROD included deed restrictions, access restrictions, well drilling restrictions and wellhead protection. Deed restrictions were placed on the property to the south of the facility in 1995 because COC were identified in ground water in this area in off-site wells KM-15 through KM-18. Kerr-McGee/Tronox subsequently purchased this property in 2004 and the deed restrictions placed on the property in 1995 are still maintained. The City of Soda Springs currently implements restrictions on land development and use through the building permit requirements, but the City does not have an enforceable means of restricting the development of ground water as a drinking water source. The property west of the facility includes a railroad right-of-way, highway right-of-way and property owned by Monsanto Chemical Company. Beneficial ground water development on any of these parcels is not likely. Ground water to the north and to the east of the site is upgradient and not impacted by the former plant operations.

3.5 Site Changes Following RI/FS Completion

3.5.1 Vanadium Plant Demolition

Although not required by the 1995 ROD or the 2000 ROD amendment, Kerr-McGee/Tronox elected to dismantle the vanadium plant between November 2001 and May 2002. Process buildings and equipment associated with the vanadium facility were razed and removed from the site. Materials removed from the site were sent to an appropriate landfill or recycled. The concrete foundations below grade were left in place. The footprint of the former plant site was covered with fine limestone. The cover was contoured to shed water away from the former plant site footprint.

3.5.2 Reclaim Lined Limestone Settling/Storm Water Runoff Ponds

Between the months of September 2003 and October 2003, Kerr-McGee reclaimed the former limestone settling/storm water runoff ponds (two lined ponds). Plans to close and reclaim the ponds were discussed in advance with the Idaho Department of Environmental Quality (IDEQ) in a number of previous meetings in early 2003, and again at a meeting at the site on July 30, 2003. IDEQ agreed that a consent order for pond reclamation would not be necessary based on their review of sediment and pond water characterization results provided to them. IDEQ agreed that sampling of the underlying material was not necessary since it was anticipated that the material would be calcine, a material that was investigated during the RI and prior to the production of the calcine fertilizer.

The water was pumped from the ponds to the 10-acre pond. The solids were then removed to the 10-acre pond along with the liners. Backfill used to regrade the site to match the existing topography was obtained from within the perimeter of the fenced area surrounding the ponds. Regrading and seeding of the pond basins occurred in October 2003. Much of the regrading material was calcine that was obtained from the pond berms, since calcine was the material that was removed when the ponds were originally excavated. Compaction was performed using the dozers and the water truck. Immediately above the regraded calcine and soil pond backfill, a nominal 8-inch layer of topsoil was placed. Following completion of cover placement, a survey was completed on the regraded surface. An estimated 6,800 cubic yards of subsoil backfill were used to regrade both ponds to match the existing site topography. Clean up of the ponds was documented in a report dated April 3, 2004 that was sent to IDEQ and to EPA.

3.5.3 Reclaim 5-Acre Ponds

The east and west 5-acre double-lined evaporation ponds were permitted through the IDEQ in 1995, and approved in a letter dated December 12, 1995. IDEQ requested in their approval letter of the 5-acre ponds that Kerr-McGee provide a closure plan prior to performing any reclamation on the ponds.

The west pond had a capacity of about 9.7 million gallons. Dimensions of the west pond measured 560 feet in an east-west direction and 400 feet in a north-south direction. The east pond had an 8.4 million gallon capacity, with dimensions of about 600 feet by 450 feet. The west 5-acre pond was sloped to a sump area at the southeast corner and the east pond was sloped to the southwest corner, at approximately 0.004 percent. Pond construction consisted of recompacted native silty clay soils placed in lifts, overlain by two 40-mil HDPE liners separated by a geonet layer. At the time that the vanadium plant was closed, the ponds were nearly completely full and could not receive any additional process water. An evaporative system was set up on each pond to reduce the volume through evaporation.

Surface waters in the 5-acre ponds were investigated in the fall of 1999 and again in 2001. Results of the analyses of were presented to IDEQ in 2003 prior to closure. Results indicated that the ponds had field pH values of 3.2 to 3.9 units. October 2001 data indicated that the ponds were elevated in sodium, magnesium, potassium, molybdenum, vanadium, chloride, sulfate, copper, nickel, arsenic, and selenium. TDS in the ponds ranged from 136,000 to 411,000 mg/l. Organics were present in the ponds, with TPH ranging from 32 to 33 mg/l. Organics present in the ponds are the breakdown products of the fuel carrier (diesel fuel) that was used in the S-X circuit, and the breakdown of tributyl phosphate into unknown semi volatile compounds.

Solids in the east and west 5-acre ponds were also sampled in October 2001. Solids included salt-like materials, soils, sediments, and fertilizer materials. The soils noted in the ponds likely resulted from a mixture of windblown calcine, windblown native soils adjacent to the ponds, and sediment precipitated from the process. Solids sampling results indicated that the pond solids were highly elevated in sodium, calcium, magnesium, potassium, vanadium, and smaller amounts of copper, nickel and molybdenum. TPH was found in the sediments and soils in the 5-acre ponds. TPH concentrations were generally less than detection in the solids. Semi volatile organics and unknown compounds were present in the sediments in trace amounts. The pH of the salts and sediments were 3.4 units to near normal. Semi-volatile organics and unknown compounds were present in the sediments in trace amounts. Sediment samples did not exceed TCLP limits therefore were not considered hazardous according to RCRA.

Soil investigations beneath the ponds were performed in March 2005 in the west 5-acre pond, approximately 4 months following cleaning out of the pond and removal of the liners. Investigations included logging of 14 test pits and collection of geotechnical soil samples in advance of a landfill design. Findings of the investigations indicated that the soils beneath the west 5-acre pond consisted of unconsolidated and nearly uniform deposits of silt and silty clay ranging in thickness from about 8.5 to greater than 16 feet. This uniformly fine-grained native soil material is of small hydraulic conductivity (typically 10^{-5} to 10^{-6} cm/sec) and rests on bedrock. Bedrock consisted of a series of volcanic basalt flows, although a veneer of travertine limestone from fresh water spring deposits is known to occur in the vicinity of the site directly beneath the soil mantle. Depth to ground water near the former 5-acre ponds is about 44 feet below ground surface, indicated by ground water levels in nearby paired wells KM-1 and KM-10.

Plans to close and reclaim the 5-acre ponds were discussed in advance with the IDEQ in a meeting on May 22, 2003 and again at a meeting at the site on July 30, 2003. The details contained within this report document the pond closures that were cleaned out and reclaimed in accordance with the methods presented to the IDEQ in the 2003 meetings. In July 2003, IDEQ agreed that a consent order for pond reclamation would not be necessary based on their review of sediment and pond water quality characterization results provided to them in 2003.

The west 5-acre pond was completely cleaned out and an estimated 7,100 yards of sludge were pumped from the west 5-acre pond to the 10-acre pond over an approximate period of twenty nine days. An estimated 5,200 yards of sludge was removed from the east 5-acre pond. The liner systems were removed by cutting with hook blades and rolling the liners into rolls approximately 3 feet in diameter. Liner materials were then transported to the northeast corner of the west 5-acre pond basin and compacted with the track hoe and loaders to further reduce the volume. Soils beneath the removed pond liners showed no visual evidence of leakage from the reclaimed ponds. At a few locations, incidental volumes of rain water runoff contacting contaminated areas ran onto the pond bottom soils. Efforts were made to remove the soils to the 10-acre pond soon after these incidents occurred. The remainder was collected and placed in the 10-acre pond prior to job completion. Following removal of the liners, the pond bottoms were surveyed to determine grade. The west pond was not regraded, but was surveyed and provided with a central drainage trench sloping to the west to prevent ponding of rain and snow melt in the basin. The west 5-acre pond basin location is proposed for additional excavation and siting of a landfill cell to receive the solids from the 10-acre pond. At the site of the reclaimed east 5-acre pond, clean backfill was used to regrade the site to match the existing topography. Backfill was obtained from within the perimeter of the fenced area surrounding the east pond. Compaction was completed using the D-8 dozer and track hoe. An estimated 14,600 cubic yards of subsoil backfill were used to regrade the east 5-acre pond to match the existing site topography and to provide positive drainage.

3.5.4 Calcine Cap Drainage Improvements

A number of drainage improvements were made around the cap to collect clean runoff water. Runoff from the calcine impoundment area was not an issue at the site prior to cap placement as the result of the increased infiltration rate through this material. In the spring of 2002 following completion of the cap, a pond formed on the north side that encroached on the cap. An infiltration basin was constructed on the north side of the calcine cap at the lowest topographic elevation immediately adjacent to the calcine cap fence line in clean soil. The project was completed in October 2002 and documented in the calcine cap infiltration basin as-built report, (GET, 2002). To date, no standing water has been noted in the depression north of the cap since the construction of this basin was completed.

Periodic standing water resulting from runoff to the west and south of the cap persisted through June 2005. Much of this standing water was present in an area south of the limestone pile, and at a location immediately south of the cap on the site of the former roaster scrubber pond. Cover grade above the former scrubber pond was maintained at or near the elevation of the road since the cover fill was placed in 1998. However, localized soil settlement resulted in low areas that periodically collected water from cap runoff. Snow accumulation south of the cap during winter months is substantial which results in increased surface water. During 2005, approximately 7,400 yards of soil were used to fill and regrade areas south of the cap. Fills ranged between 0.5 to about 7 feet. The site was graded such that drainage in the basin south of the cap sloped gently to the west toward an infiltration basin that was constructed south of the former scrubber pond in a barley field.

4.0 REMEDY EVALUATION

4.1 Description of Evaluation Tasks

4.1.1 Former S-X Pond Basin

The Addendum I work plan included an inspection of the former S-X pond basin area. The covered area of the former S-X pond shown on Figure 4-1 was inspected in 2008 to observe for evidence of erosion, deep tap-rooted plants, burrowing animals and areas where standing water may have been present following snow melt. The purpose of this inspection was to determine if a potential exists for infiltration of concentrated surface water runoff through the former pond basin. This inspection was completed by initially establishing 50-foot grid on the former S-X pond cover. The grid lines were established in a north-south and east-west direction. The grids were set in the field by placing stakes or flagging at 50-foot intervals on each side of the S-X pond basin using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid completely encompassed the footprint of the cover. The grid points across the entire pond basin were located using a Garmin Colorado 400t hand-held GPS. More details concerning this inspection are presented in Appendix A to this report.

Each grid line was inspected for any of the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not hinder the observer. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS.

4.1.2 Former Scrubber Pond Basin

The Addendum I work plan included an inspection of the former scrubber pond basin area. The covered area of the former scrubber pond shown on Figure 4-2 was inspected to observe evidences of erosion, deep tap-rooted plants, burrowing animals and areas where standing water may have been present following snow melt. The purpose of this inspection was to assess the potential for infiltration of concentrated surface water runoff through the former pond basin. This inspection was completed by establishing a 30-foot grid on the former scrubber pond cover footprint. The grid lines were oriented in a north-south and east-west direction. The grids were established by placing stakes or flagging at 30-foot intervals on each side of the scrubber pond basin using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire pond basin were located using a Garmin Colorado 400t hand-held GPS.

Each grid line was inspected for the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not hinder the observer. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS. Details are presented in Appendix A.

4.1.3 Former Limestone Settling Ponds

The Addendum I work plan included an inspection of the former limestone settling pond area. The covered areas of the former limestone settling ponds, areas shown on Figure 4-3 were inspected in 2008 for signs of erosion, deep tap-rooted plants, burrowing animals and areas where standing water may have been present following snow melt. The purpose of this inspection was to determine if there is a potential for infiltration of concentrated surface water runoff through the former pond basin. This inspection was completed by establishing a 50-foot grid on the limestone settling pond area. The grid lines were set in a north-south and east-west direction. The grids were established by placing stakes or flagging at 50-foot intervals on each side of the limestone settling pond area using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire pond basin were located using a Garmin Colorado 400t hand-held GPS.

Each grid line was inspected for the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not obscure site features. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS. Details of the inspection are presented in Appendix A.

4.1.4 On-Site Landfill

The Addendum I work plan included an inspection of the on-site landfill. Details of the inspection are presented on Figure 4-4. The on-site landfill was inspected in 2008 to look for signs of erosion, deep tap-rooted plants, burrowing animals, tension cracks, settlement and areas where standing water may have been present following snow melt. A water sample was obtained from the landfill sump for chemical analysis in October 2008. The purpose of this inspection was to assess the potential for infiltration of concentrated surface water runoff through the landfill. This inspection was completed by establishing a 50-foot grid on the on-site landfill cap. The grid lines were set in a north-south and east-west direction. The grids were established by placing stakes or flagging at 50-foot intervals on each side of the on-site landfill cap using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire area were located using a Garmin Colorado 400t hand-held GPS.

Each grid line was inspected for any of the conditions listed above. The field engineer looked for settling around the well that is used to remove water from the sump. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not hinder the observer. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS.

Although the 2002 and 2007 five year reviews stated that the landfill was constructed as designed this evaluation included a review of the landfill construction documents. The purpose of the landfill construction review was to determine if the landfill was constructed as designed. The operation and maintenance documentation was reviewed to determine if the inspections and other O&M procedures described in the approved landfill design document were being completed as required.

4.1.5 Calcine Cap

The Addendum I work plan included an inspection of the calcine cap. Details are presented on Figure 4-5. The calcine cap was examined for evidence of erosion, deep tap-rooted plants, burrowing animals, tension cracks and areas where standing water may have been present following snow melt. The purpose of this inspection was to determine if there is a potential for infiltration of concentrated surface water runoff through the calcine cap. This inspection was completed by establishing a 50-foot grid on the cap. The grid lines were set in a north-south and east-west direction. The grids were established by placing stakes or flagging at 50-foot intervals on each side of the cap using a compass and tape. Stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire capped area were located using a Garmin Colorado 400t hand-held GPS. The outside edge of the calcine cap was walked to determine if there is evidence of water flowing out of the geonet that could lead to erosion and possible failure of the liner system.

Each grid line was inspected for any of the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not hinder the observer. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS.

Although the 2007 5-year review stated that the cap was constructed as designed this evaluation included a review of the calcine cap construction documents. The purpose of this review was to determine if the calcine cap was constructed as designed. The operation and maintenance documentation was reviewed to determine if the inspections and other O&M procedures described in the approved calcine cap design document were being completed as required.

4.1.6 Former MAP Ponds

The Addendum I work plan included an inspection of the former MAP ponds area. Details are presented on Figure 4-6. The uncapped area of the former MAP ponds, now partially covered by a site building formerly used for calcine dewatering, was inspected in 2008 to investigate evidence of erosion, deep tap-rooted plants, burrowing animals and areas of settlement where standing water may have been present following snow melt. The purpose of the inspection was to determine if there is a potential for infiltration of concentrated surface water runoff through the MAP ponds area. This inspection was completed by establishing a 50 foot^2 grid on the areas of the former MAP ponds. The grid lines were set in a north-south and east-west direction. The grids were established by placing stakes or flagging at 50-foot intervals on each side of the former pond area using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire pond area were located using a Garmin Colorado 400t hand-held GPS.

Each grid line was inspected for any of the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not hide noteworthy features. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS.

4.1.7 Former Vanadium Plant

The Addendum I work plan included an inspection of the former vanadium plant area. The uncapped area of the former vanadium plant was inspected for cover amount and to observe whether former features of the plant remain above the cover. The plant footprint was inspected for erosion, signs of vegetation, burrowing animals and areas where standing water may have been present following snow melt. The purpose of the 2008 inspection was to determine if there is a potential for infiltration of concentrated surface water runoff through the former vanadium plant area or whether a potential exists for impacts from the former facility to ground water. The inspection was completed by establishing a 50-foot by 50-foot grid on the former plant area. The grid lines were set in a north-south and east-west direction. The grids were established by placing stakes or flagging at 50-foot intervals on each side of the on-site landfill cap using a compass and tape. These stakes were used to align the field engineer during the inspection to ensure that the grid was covered. The grid points across the entire former plant area were located using a Garmin Colorado 400t hand-held GPS.

Each grid line was inspected for any of the conditions listed above. The field engineer walked slowly enough so that the areas on both sides of the grid line were observed and so that the vegetation did not obscure noteworthy features. The field engineer walked the grid lines in both the north-south and east-west directions. Observations made while walking each grid line were recorded in a field notebook. Photographs were taken of each problem area that was observed during the inspection. These problem areas were located using the hand-held GPS.

4.1.8 Additional Geochemical Assessment

In order to assess potential geochemical factors potentially influencing COC concentrations in ground water and surface water, Tronox collected dissolved oxygen (DO) and oxygen-reduction potential (ORP) field parameters in October 2008 during the semi annual sampling event. These additional field parameters were added to gain a better understanding of the redox conditions beneath the site in ground water. Additional analytes added to the list for the laboratory included dissolved iron, dissolved manganese, ammonia, total organic carbon (TOC), and silica.

4.1.9 Institutional Controls

The institutional controls that have been in place since 1995 were reviewed. These controls were compared to the requirements found in EPA 540-F-00-005 OSWER 9355.0-74FS-P dated September 2000.

4.2 Results of Remedy Evaluation

4.2.1 Former S-X Pond

Ground water sampling analytical results indicated that the ground water to the south of the former S-X pond remains among the most heavily impacted ground water areas for COC beneath and downgradient of the site. This observation is made in ground water for the periods during vanadium production, S-X pond operation and following LSE.

The former S-X pond water was sampled during the RI. Results indicated that the S-X water contained up to 117 mg/l vanadium, the largest concentration of all liquid sources identified on site that discharged to unlined ponds. Molybdenum concentrations were large in the S-X pond. RI results indicated molybdenum at concentrations as large as 155 mg/l in the S-X stream that flowed through the limestone settling ponds and to the former S-X pond. The largest concentrations of 12 of 26 detected metals during the RI were found in the limestone settling ponds and in the S-X pond. Conclusions made during the RI were that the inorganic constituents in the S-X circuit waters were up to three orders of magnitude larger than other uncontained liquid pond discharges. Sediments removed from the bottom of the S-X pond were elevated in both molybdenum (444 mg/kg) and vanadium (7770 mg/kg). The sediments were removed from the pond basin to native soils or calcine prior to covering the scraped pond with a soil cover.

The RI does not indicate that any investigative methods, such as soil borings were performed in this area, nor were samples obtained from the remaining soils or calcine underlying the removed sediment prior to recovering the pond basin with soils. Soil thickness in the S-X pond basin area ranges from about 10 to 22 feet. The soils include silty clay of low to medium plasticity, formation rock, caliche, calcine tailing and silt. Soil descriptions are based on the logs for wells KM-7 KM-8, KM-12, KM-13, KM-19, and boring B-2. None of the borings were completed in the pond basin. Therefore, the soil conditions are relatively unknown beneath the S-X pond basin.

As part of the remedy evaluation, an inspection of the former S-X pond area was conducted between July 17 and August 6, 2008. The inspection included surface conditions evaluations only. Details are presented on Figure 4-1. After a reconnaissance of the site area, the inspection grid was established as previously described and described in Appendix A. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

The former S-X pond area is covered with vegetation that is mainly wheat grass and other grasses. No deep tap-rooted plants were observed during the inspection. The inspection was conducted in late July and the plant growth was complete and the grasses had already produced heads. The vegetation within the former pond area was shorter and was starting to turn brown when compared to the grasses outside the former pond area indicating stress.

The inspection showed numerous areas that may have contained standing water following snow melt, several areas of erosion, areas of exposed calcine, a few burrowing animal holes and one possible sink hole within the boundaries of the former pond. The areas that showed evidence of holding water were scattered throughout the pond area and ranged in size from relatively small to greater than 100 ft^2 in size. The areas of erosion and exposed calcine were observed along the eastern side of the former pond. The sink hole was observed near the western edge of the pond (Line 4 and Point 5). The sink hole is approximately 2.5 feet in diameter and 1.5 feet deep. The larger areas indicating standing water, areas of erosion, exposed calcine and the sink hole are shown on Figure 4-1.

4.2.2 Former Scrubber Pond

The S-X pond discharge was frequently rerouted to the scrubber pond, as discussed in the RI and indicated in Table 1-1. The S-X pond and the limestone settling pond waters were shown in the RI to have the larger COC concentration when compared with other unlined pond discharges. During the RI, one sample of scrubber pond water and two sediment samples were obtained from the scrubber pond. Molybdenum concentrations were generally much smaller in scrubber pond water and sediments when compared with the S-X pond media. However, the vanadium concentrations in the scrubber water and scrubber sediments that were removed from the pond prior to closure were about an order of magnitude less than the S-X pond.

The RI does not indicate that any investigative methods, such as soil borings were performed in the scrubber pond basin soils, nor were samples obtained from the remaining soils or calcine underlying the removed sediment prior to recovering the pond basin with soils. Soil thickness in the scrubber pond basin area is substantially greater than at other locations on the plant site, ranging from about 10 to 47 feet. The soils include silty clay of low to medium plasticity, calcine tailing, and silty sand. Soil descriptions are based on the logs for wells KM-2 KM-3, and boring B-10. It is possible that some of the alluvial sequence beneath the former scrubber pond is saturated based on RI investigation results. None of the RI borings were completed in the pond basin. Because no borings or samples were obtained from beneath the scrubber pond, the conditions beneath this pond basin are relatively unknown. Ground water sampling analytical results for wells KM-2, KM-3 and KM-4 continue to indicate that the shallow ground water in the vicinity of the former scrubber pond is heavily impacted from COC. This observation is made in ground water for the periods during vanadium production, scrubber pond operation and for the RD/RA period following LSE.

The scrubber pond cover receives a greater amount of moisture than would normally occur as the result of the runoff from the calcine cap, located immediately to the north of the scrubber pond. Approximately 35 percent of the cap will drain directly to the scrubber pond cover. Runoff models performed for the calcine cap during the design indicated that runoff from the cap varies from about 4,400 to 235,000 cubic feet per year with an annual average of 99,810 cubic feet. Therefore, on an annual average, the scrubber pond cover potentially receives about 35,000 cubic feet of water generated off the cap. An infiltration basin was installed to infiltrate this water in a non-impacted vadose zone area.

Periodic standing water resulting from runoff to the south of the cap was noted between 2002 and 2005 on the former pond cover. During that time, localized soil settlement on the scrubber cover resulted in lowered areas that periodically collected water from cap runoff. Snow accumulation south of the cap on the scrubber pond cover during winter months was substantial as the result of previous excavations south of the former pond that held snow. This area was regraded in 2005 to eliminate snowpack on the scrubber cover and to provide positive drainage. Approximately 7,400 yards of soil were used to fill and regrade areas south of the cap. Fills ranged between 0.5 to about 7 feet. The site was graded such that drainage in the basin south of the cap sloped gently to the west toward an infiltration basin that was constructed in clean native soil in the agricultural field to the south of the site.

As part of the remedy evaluation during 2008, an inspection of the closed and covered scrubber pond area was conducted between August 6 and August 9, 2008. Details are presented on Figure 4-2. Following a brief reconnaissance of the area, the inspection grid was established as previously described and described in Appendix A.

A grid system was initially established on the scrubber pond cover. Next, the field engineer walked the grid along the east-west and north-south lines. Where the field engineer observed areas of erosion, evidence of burrowing animals, deep tap-rooted plants or areas standing water that may have been present, the area was located using the hand-held GPS and a photograph of the area was taken. Noted areas are shown on Figure 4-2. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

Results of the inspection indicate the former pond area is covered with vegetation that is predominantly wheat grass and other grasses. One deep tap-rooted plant was observed during the inspection. This plant was a member of the sagebrush family, silver sagebrush. The intrusion of this plant was limited to the eastern half of the former scrubber pond. The 2008 inspection showed numerous barren areas that likely contained standing water following snow melt. The areas that showed evidence of standing water were located principally on the western half of the pond cover. A number of locations of barren areas are observed on the eastern portion of the cover. The largest areas that indicate settlement and appear to hold water are close to the trenches dug to install the piping for the infiltration galley that drains the west side of the cap runoff water. These trenches are filled with cinders to allow the water to infiltrate into the French drain, but there is evidence that the volume of water that is present in this location is greater than the capacity of the French drain and water stands on the surface for some time. The eastern portion of the pond area has a few feet of additional fill that creates a small hill in this area. The larger areas that could hold water and the area that contains additional fill material are shown on Figure 4-2.

Based on the results of the 2008 inspection, it is clear that settlement continues to occur on the scrubber pond cover and that runoff from the cap contributes to standing water on the cover. It is not clear whether the continued settlement since 2005 is the result of cover settlement or whether settlement is occurring within the soils beneath the former pond.

4.2.3 Limestone Settling Pond Area

As shown on Figure 1-4, three unlined and two lined limestone settling ponds were located directly to the east of the S-X pond cover. The ROD did not require the removal of these ponds. During the RI, one water sample and one sediment sample were obtained from the settling ponds for organics analysis. Results indicate that the sediment in the limestone settling ponds was similar to the S-X sediments with respect to organic COC concentrations. Monitor well drilling and soil boring investigations were performed in the vicinity of, but not directly in the former limestone settling ponds during the RI. Findings indicated that the site occupied by the reclaimed limestone settling ponds is underlain by calcine and unconsolidated deposits of silt and silty clay ranging in thickness from 13 to 15 feet, as shown in cross section of the reclaimed ponds prior to reclamation on Figure 4-7. This fine-grained native soil material is of low hydraulic conductivity and rests on bedrock. Bedrock is predominantly a series of volcanic basalt flows to depths of approximately 200 feet. Depth to ground water is about 30 to 40 feet below ground surface.

The S-X raffinate was contained within a series of these ponds that allowed limestone to settle and clarify prior to discharging to the former S-X pond. Between 1974 and 1988, three unlined settling ponds used in the vanadium solvent extraction process were present at this location. These ponds settled neutralizing limestone fines en-route to the unlined S-X pond, and were covered by 1988. These ponds ranged in capacity from 500,000 to 1,000,000 gallons. A fourth pond (approximately 0.4 acres) experienced two failures in 1989. The pond was reconstructed and lined with a 30-mil single liner following these failures. A fifth pond of nearly identical size was constructed and lined immediately west of this pond, and brought on line in 1993. The fourth and fifth ponds were eventually used for the storm water runoff from the historic vanadium plant once a new series of lined ponds was constructed. Configuration of all of these historic ponds is shown in Figure 1-4. The lined settling ponds were closed in 2003 during a voluntary cleanup action by Kerr-McGee. Prior to excavation of the sediment, the contractor removed incoming PVC drain piping from the east pond. The sediments, water and liners were removed from the final two ponds and placed in the 10-acre pond. Volume of sediment was estimated to be about 4,500 yards. An estimated 6,800 cubic yards of subsoil backfill were used to regrade both ponds to match the existing site topography.

The inspection of the former limestone settling pond area was conducted on August 10, 2008. After a brief reconnaissance of the area, the inspection grid was established as previously described and described in Appendix A. Details of the inspection are presented on Figure 4-3.

After the grid system was established, the field engineer walked the grid along the east-west and north-south lines. Areas of erosion, evidence of burrowing animals, deep tap-rooted plants or areas standing water were located using the hand-held GPS and a photograph of the area was also obtained. Noted areas are shown on Figure 4-3. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

The covered limestone settling pond area is covered with vegetation that is mainly wheat grass and other grasses. Several deep tap-rooted plants were observed during the inspection. These plants included several species of brush. The most noteworthy feature is a marshy area that exists in the central part of the former pond site. The source of the water is assumed to originate from the former vanadium plant facility through a pipeline. This water source may be plant runoff, although water on the surface appears to persist into late summer. Two areas of cattails were observed within these marshy areas. Both of these areas were associated with standing water and are likely to overlie buried calcine deposits and promote COC generation within the vadose zone. The source of the water to these ponded areas could not be confirmed. The two areas of standing water appear to be connected but the means of water transport was not readily evident. A drainage ditch from the eastern body of standing water has been constructed to divert water to the northwest. Water discharging from the western body of water flows to the west and has produced several erosion rills. These areas of standing water and erosion rills are shown in Figure 4-3.

4.2.4 On-Site Landfill

The S-X pond was taken out of operation during 1996. During November 1996, the S-X pond sediments and underlying soils were scraped to the south end of the pond and covered with plastic. This allowed an extended period of time for the S-X solids to dry and consolidate. The scrubber pond came out of service in April 1997 and was drained prior to sediment thickness investigation. Therefore, the scrubber solids contained a higher percentage of moisture compared with the S-X solids.

The on-site landfill is a multiple liner containment facility holding the scrubber and S-X solids that was constructed to meet RCRA-D design landfill facility requirements. The facility is essentially rectangular in shape. The cell was over excavated by three feet so that the silt foundation could be recompacted in 12-inch lifts to optimum moisture and compaction. Settlement of the landfill is expected to be negligible since the bottom lift rests directly on or just above the bedrock surface. However, geotechnical consolidation testing performed on samples of these soils indicated that the soils are slightly over-consolidated with limited immediate compressibility of the soil upon loading. Falling head permeability tests were completed on recompacted soil samples.

Results ranged from about 8.2 x 10^{-7} to 1.7 x 10^{-6} cm/sec. Laboratory compaction testing indicated that a substantial decrease in soil permeabilities resulted from recompacting the native soil samples.

For these loess-type soils, compaction tests were performed using the Standard Proctor Test ASTM D698. Tests results indicated maximum soil densities for these soils are approximately 104 to 106 pounds per cubic foot (pcf) with optimum soil moisture content of about 19 percent. A minimum of 4 density tests were performed for each lift. Difficulties that were initially encountered during compaction of the base and the side slopes of the cell were the result of not having enough moisture to achieve optimum compaction. This was resolved by the QC engineer ripping out soil lifts and then recompacting, and specifying additional water trucks and water applications to the soils. Compaction was in nearly all cases 90 to 97 percent. Compaction more indicated this phase of the into silt materials that were recompacted.

A secondary liner (a GCL) was placed on the smoothed and compacted surface. Apparently some of the GCL became hydrated but was not removed and was handled according to the manufacturers recommendations. Soils were comprised of silts with almost no sand. Therefore, the surface was completely smooth and accepted by the liner contractor, documented in the remedial action completion report. A primary liner (60-mil HDPE liner) was placed directly on the GCL, with a geocomposite layer placed directly on the geocomposite. Directly above the geocomposite, an 18-inch soil cushion layer was placed to protect the geocomposite. A sump was constructed into the lowest level of the landfill with coarse gravel surrounding the screen inlet. This sump was installed to remove residual construction water used in the compaction of the waste materials from the scrubber and S-X ponds.

A mixture ratio of approximately 3:1 scrubber to S-X waste was windrowed and premixed before placement into the landfill to achieve the most desirable moisture content and maximum compaction. Following removal of the waste from the pond basins, as confirmed by the IDEQ and EPA, an 18-inch layer of native silt soil was placed directly on the compacted waste. Directly on the compacted native soil layer, a flexible membrane cover consisting of liner low density polyethylene (LLDPE) was placed into an anchor trench outside of the liner trench. A geocomposite layer was placed directly on the LLDPE and anchored into the same trench. Three feet of native soil was placed on this geocomposite in 8-inch loose lifts.

During the last week of September, the Idaho Department of Environmental Quality (IDEQ) inspected the pond basins and determined that all of the pond solids had been removed from the pond basins prior to bringing in clean native soil for cover material. Pond reclamation activities occurred during the last week of September and during the first week of October. Following removal of sediment materials from the pond basins and approval of closure from the IDEQ, completeness of sediment removal from pond basins was documented with photographs. Dikes were pushed in at both pond basins, and 2 feet of clean native soils were imported into the basins to cover the excavated grades. The overall site slopes were graded and sloped to enhance runoff away from the preexisting pond locations. Both sites were top soiled and seeded during 1997.

The landfill sump is pumped to a concrete holding sump that has been specifically coated for chemical resistance. The landfill was pumped to the west 5-acre pond through September 2004. The landfill is pumped about 4 to 6 times per year, discharging up to several hundred gallons. Analyzed results indicate about 150,000 ug/l molybdenum and 30,000 ug/l vanadium in these waters bailed from the sump.

The 2008 inspection of the on-site landfill cover was conducted August 10, 2008. Details of the inspection are presented on Figure 4-4. After a brief reconnaissance of the area and review of the landfill monitoring log, the inspection grid was established as previously described and described in Appendix A.

After the grid system was established, the field engineer walked the grid along the east-west and north-south lines. Discernable areas of erosion, evidence of burrowing animals, deep tap-rooted plants and areas standing water may have been present were located using the hand-held GPS. Noted areas are shown on Figure 4-4 Photographic documentation was completed. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the noted items and issues are attached in Appendix A.

The on-site landfill cap is covered with vegetation that is mainly wheat grass and other grasses. Several deep tap-rooted plants were observed during the inspection. These plants included alfalfa and an unidentified plant. The intrusion of these plants was limited to the north slope of the landfill cap outside of the landfill cover anchor trench limits, but within the fenced area.

There was evidence of burrowing animal activity at several locations in the landfill area. The depth of these holes could not be determined at the time of the inspection because the holes had already caved in and did not appear to be active. Some of these may possibly be shallow coyote diggings. There was no settling observed around the sump well or at other locations on the landfill cap. The area along the southern fence is bare of vegetation. There are two other areas barren of vegetation just east of the western fence (near point 6 between lines 5 and 6 and near point 6 on line 7). These noted areas are shown on Figure 4-4.

Prior to the inspection of the on-site landfill the inspections records completed and maintained by Tronox were reviewed. This review is discussed in Appendix A. These records demonstrated that the water in the sump was being pumped out periodically. However, these records did not document many of the cover inspections of the landfill area completed by Tronox for the past few years. This does not indicate that the work was not performed, but rather that the work was not documented in the monitoring log. Currently, the fence around the landfill is in good condition and both gates are locked.

4.2.4.1 Landfill Construction Evaluation

As part of the remedy evaluation, the construction documents for the landfill were reviewed by a registered professional engineer. Construction of the on-site landfill is described in the Draft Remedial Action Completion Report (GET, March 1998). The design document (TriTechnics, May 1997) and the completion report referenced above were reviewed as part of the remedy evaluation for the on-site landfill. Based on the review the information contained in these documents, all aspects of the landfill construction were completed as designed. The construction of the on-site landfill was completed between July and November 1997. The design document (Remedial Design/Remedial Action Final Landfill Design Plans and Specifications) was prepared by TriTechnics in May 1997. This design was subsequently approved by EPA. The designed called for excavation and recompaction of the foundation soils, installation of the geosynthetic clay liner (GCL), installation of the primary liner (60-mil high density polyethylene (HDPE)), installation of the lower geocomposite drainage layer, installation of the protective soil layer, installation and compaction of the waste materials, installation the 40-mil linear low-density polyethylene flexible membrane cap, installation of the upper geocomposite drainage layer, installation of the soil cover, seeding of the soil cover and installation of the chain link fence.

As part of the landfill construction management plan construction oversight was provided by Gordon Brown of the Idaho Department of Environmental Quality (IDEQ). Following completion of construction a final inspection was conducted on November 5, 1997 by Gordon Brown of IDEQ, Peter Contreras of EPA and representatives from Kerr-McGee. Following this inspection, EPA and IDEQ agreed that the construction was complete.

Construction of the on-site landfill is described in the Draft Remedial Action Completion Report (GET, March 1998). The design document (TriTechnics, May 1997) and the completion report referenced above were reviewed as part of the remedy evaluation for the on-site landfill. This review is presented below.

Site Excavation and Foundation Construction

The design called for excavating the landfill to a depth three feet lower in elevation than the final grade elevation. This soil was stockpiled so that it could be used to construct the recompacted floor of the landfill. The documentation indicates that the excavation was completed as designed and was verified by the licensed surveyor and construction quality assurance (CQA) inspection engineer assigned to the project.

The design called for a minimum of 8 inches of the landfill foundation be scarified and re-compacted. This was accomplished using paddle-footed rollers and loaded scrapers. Construction of the foundation was completed by placing the excavated soil in the bottom of the landfill in 8-inch lifts and then compacting each lift. At least 4 density measurements were made on each lift for the floor and all four berms of the landfill foundation. The documentation indicates that water was added to the soil followed by additional compaction, additional compaction was performed, portions of a lift were removed and replaced or the soils were allowed to dry followed by additional compaction at several locations before additional density testing showed that the area met the compaction requirements. The documentation indicates that the entire foundation met the compaction requirements of the project.

Geosynthetic Clay Liner (GCL) Installation

The contractor hired to place the GCL inspected the foundation of the landfill and provided written acceptance of the foundation. This written acceptance is included in the documentation. The documentation contains the quality control certificates for each roll of GCL received from the manufacturer. All of the GCL material used to construct the landfill met the requirements of the project.

The CQA inspection engineer observed the unloading of each truckload of GCL. The documentation indicates that none of the rolls were damaged during the unloading process. All of the rolls were covered to protect them from the weather.

The design called for running the GCL panels down the grade and not across the grade. The as-built drawing shows that the GCL panels were installed as designed. The panels in the corners of the landfill were oddly shaped and the as-built drawing shows that these panels were installed down the grade. The documentation indicates that the GCL was lapped as required and that bentonite powder was placed between the two panels at each point there was an overlap. According to the documentation total of 80 GCL panels were installed.

GCL placement was not conducted during a rain storm or within standing water. The documentation indicates that the GCL was covered by the 60-mil HDPE material to protect the GCL from the elements. On August 18, 1997 a sudden rainstorm that lasted about 20 minutes prematurely hydrated several GCL panels on the berm of the landfill before they could be covered by the HDPE material. The documentation indicates that this event was investigated and the decision to leave the panels in place was made. Based on the information in the documentation, this appears to be a correct decision and the integrity of the construction was not compromised.

60-mil HDPE Flexible Membrane Liner (FML) Placement

The 60-mil HDPE material used to construct the liner met the quality requirements of the project. The Remedial Action Completion Report (GET, 1998) contains the quality control certificates for all of the rolls used. The as-built drawing in the documentation shows that the FMC panels were placed running downhill as required by the design. The odd shapes needed to complete the corners of the landfill were placed to minimize wrinkling and ran downhill. A total of 33 panels were used to construct the primary liner of the landfill.

The quality control activities for the liner installation included logging the liner material when it was received. This log includes the roll number, batch number, roll size and any damage to the roll. This allowed for tracking each roll from the time it was received through the time it was used.

During the seaming operation, trial seams were completed twice a day and the seam tested in the field for peel strength. This testing was done on extrusion and fusion welds. There were a few cases where the fusion trial welds did not meet the project requirements for peel strength. In these cases the settings on the welder were changed to produce a seam that met the peel strength requirements. All of the extrusion trial seams met the peel strength requirements of the project.

The project called for destructive and non-destructive testing of the seams. The destructive test samples were cut from a seam. A total of six destructive test samples were tested. Four of the samples were tested for peel and shear strength in the field. Two samples were sent to an outside lab for testing. In all cases the seams met the peel and shear strength requirements of the project. The liner was repaired according to the project requirements following the collection of each sample.

Each seam underwent non-destructive testing. This testing was done by applying air pressure along the entire length of the seam or vacuum box to test repair seams. In all cases this testing showed that the seams met the requirements of the project.

Geocomposite Drainage Layer Placement

The CQA inspection engineer inspected and logged each roll of geocomposite as it arrived at the site. Any damage was noted on the form. The certificate of analysis for this material shows that it meets the requirements of this project.

The as-built drawing shows that 57 panels were installed. The panels ran downhill in all cases. There were continuous panels placed in each corner of the landfill. The photo log verifies that the protective layer was placed on the geocomposite before any waste material was place in the landfill.

Sump Construction

The leachate collection sump was installed in the location required by the design. The sump pit was lined with all three liner materials and then filled with gravel that was wrapped by nonwoven geotextile. The 6-inch schedule 80 PVC riser was installed as required. This riser can be seen coming through the vegetative cap that covers the landfill. The riser is clear of obstructions and has been used to measure water depth in the sump and a pump has been installed in the sump through this riser to evacuate water that accumulates in the sump.

Placement of Waste Material

The sludge for the S-X and scrubber ponds was placed in the landfill in lifts. Each lift was compacted using a pad footed roller, loaded scrapers and dozers. The compaction of each lift was tested to determine if there had been sufficient compaction. At least four density measurements were made on each lift. The documentation shows that the compaction of each lift met the requirements of the project.

The surface of the waste material was rolled smooth. The liner contractor inspected the surface and found it to be acceptable for placement of the 40-mil linear low-density polyethylene (LLDPE) material. This certification is part of the documentation.

40-mil LLDPE Flexible Membrane Cover (FMC) Installation

The rolls of 40-mil LLDPE were inspected and logged by the CQA inspection engineer when they arrived at the site. Any damage to this material was noted and the damaged material was not used. The material met the specification of the project as shown by the quality certificates that are part of the documentation.

The as-built drawings show that 10 panels of the LLDPE material were installed over the waste material. These panels ran north and south.

During the seaming operation, trial seams were completed twice a day and the seam tested in the field for peel strength. This testing was done on extrusion and fusion welds. The documentation shows that all of the trial seams met the peel strength requirements of the project.

The project called for destructive and non-destructive testing of the seams. The destructive test samples were cut from a seam. A total of 5 destructive test samples were tested. Four of the samples were tested for peel and shear strength in the field. One sample was sent to an outside lab for testing. In all cases the seams met the peel and shear strength requirements of the project. The liner was repaired according to the project requirements following the collection of each sample.

Each seam underwent non-destructive testing. This testing was done by applying air pressure along the entire length of the seam. In all cases this testing showed that the seams met the requirements of the project.

Geocomposite Drainage Layer Placement

The CQA inspection engineer inspected and logged each roll of geocomposite as it arrived at the site. Any damage was noted on the form. The certificate of analysis for this material shows that it meets the requirements of this project. The as-built drawing shows that 46 panels were installed. The panels ran east west and the drawing shows that the geocomposite material went beyond the extent of the LLDPE cover in all directions.

Soil Cover and Vegetation

The geocomposite layer was covered by subsoil and top soil. The design called for at least 2 feet of subsoil and 1 foot of topsoil. The completion report (GET, 1998) states that this amount of material was placed, and the field notes indicate that the earthwork contractor measured the depth of each material as it was being placed. The 2008 field inspection noted that there was drainage off of the cover surface.

The surface was seeded with a mixture of grasses. The field inspection conducted in 2008 shows that the vegetation is doing well and is well established.

Security Fence

The landfill design called for a security fence around the perimeter of the landfill. This fence was constructed in 1997 following the construction of the landfill. The fence is in good condition.

Regulatory Agency Oversight

The landfill design was submitted to US EPA Region X for review. The design was approved by the EPA prior to construction commencing. Regulatory agency oversight of the landfill construction was provided by Gordon Brown of the Idaho Department of Environmental Quality (IDEQ). Mr. Brown was on-site for most of the construction and was present whenever the construction moved into a new phase. The EPA project manager, Peter Contreras, was informed of the progress and any problems during the construction. Both of these individuals were at the site on November 5, 1997 to conduct a final inspection of the landfill construction. Following this inspection, EPA and IDEQ agreed that the construction was complete.

Conclusions

Based on the review the information contained in the design and completion report documents, all aspects of the landfill construction were completed as designed.

4.2.5 Calcine Cap

The calcine tailing capped during 2001 was impounded in an alternating series of diked ponds on the east side of the plant site. The calcine impoundment was located on top of native soils that include silts and silty clays. The silts and clays have vertical hydraulic conductivities that range from 1 X 10^{-5} to 1 X 10^{-4} centimeters per second (cm/sec) (GET, 2000). These sediments reduced seepage rates from the calcine ponds. The dikes were constructed using calcine with native soil, or native soil borrowed from on-site locations adjacent to the facility.

Calcine is the generic term for the fine-grained, cohesionless black-colored sandy material resulting from vanadium production. Calcine tailing was originally impounded on the west side of the plant for the first ten years of plant operation in the vicinity of the S-X pond and limestone settling ponds. In 1973, this west calcine area shown on Figure 1-4 was covered with topsoil and seeded. Calcine was deposited after this time on the east side of the site as shown on Figures 1-3 and 1-4 until the closure of the vanadium plant.

Calcine was characterized in the RI (Dames & Moore, 1995). Chemical analysis of the calcine obtained during the RI in the calcine tailings area included four samples (CAL-l, CAL-2, CAL-3, and CAL-4). Metals in the calcine included chromium (567 to 685 mg/kg), copper (1,220 to 1,380 mg/kg), molybdenum (9.6 to 13.3 mg/kg), manganese (654 to 915 mg/kg), nickel (1,210 to 1,490 mg/kg) and vanadium (1,550 to 2,000 mg/kg). While vanadium was detected in calcine at concentrations of 1,550 to 2,000 mg/kg, very little molybdenum is associated with the calcine.

One calcine pond water sample was obtained during the RI for analysis. Calcine pond water results indicated that vanadium concentrations were found at levels (89,600 ug/l) comparable with the S-X pond raffinate water (117,000 ug/l), but that molybdenum concentrations (2400 ug/l) were about two orders of magnitude smaller than the S-X water (155,000 ug/l). One lysimeter (L-3) was placed in the calcine area during the RI.

Concentrations of soil water samples from lysimeter L-3 indicated molybdenum (up to 13,000 ug/l) and vanadium (up to 586,000 ug/l). These results were about an order of magnitude larger than concentrations observed in the calcine pond water.

During 2008, the inspection of the calcine cap was conducted on August 16 and 17, 2008. After a brief reconnaissance of the area, the inspection grid was established as previously described and described in Appendix A. Details of the inspection are presented on Figure 4-5. The field engineer walked the grid along the east-west and north-south lines. Where the field engineer observed areas of erosion, evidence of burrowing animals, deep tap-rooted plants or areas standing water, the area was noted and located using the hand-held GPS. Photographs of the areas of interest were also obtained of the cap cover. The photo log of the cover evaluation inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

Results of the cap inspection indicate that the calcine cap is covered with vegetation that is mainly wheat grass and other grasses. Several deep tap-rooted plants were observed during the inspection. These plants included alfalfa, goldenrod, sagebrush and members of the thistle family. The intrusion of these plants is predominately on the south, east and north slopes of the calcine cap.

There was evidence of burrowing animal activity at several locations in the capped area. The depth of these holes could not be determined at the time of the inspection because the holes had already caved in and did not appear to be active. There was no settling observed on the surface of the cap. There is evidence of some erosion occurring on the south facing slope of the cap. The erosion is not substantial at this time, may not be currently active, but could worsen if steps are not taken to correct this problem. The fence around the calcine cap is in good condition and the gate is locked.

4.2.5.1 Calcine Cap Construction Evaluation

The Addendum I work plan included an evaluation of the calcine cap construction details. As part of the remedy evaluation, the construction documents for the calcine cap were reviewed by a registered professional engineer. Following the engineering review, the engineer concluded that the calcine cap was constructed in accordance with the design plans and specifications.

The calcine cap design and construction activities were described in the Draft Remedial Action Project Implementation Plan and Final Design Plans and Specifications (GET, May 2000). This document was subsequently approved by EPA and construction of the calcine cap began in October 2000 with the excavation, transport and compaction of the calcine material stored at the Evergreen facility in the northwest area of the calcine impoundment. Construction activities began again in May 2001 and construction was completed in August 2001. The design of the calcine area cap included transportation of the roaster reject material and off-spec fertilizer into the calcine area, regrading and compaction of the material in the calcine area, installation of 40-mil linear low density polyethylene (LLDPE) flexible membrane cover, installation of a geocomposite drainage layer, placement of the soil cover, seeding of the soil cover and installation of the security fence around the calcine cap area. The construction of the calcine cap is described in the Draft Remedial Action Completion Report – Calcine Capping (GET, February 2002).

Calcine Area Contouring and Compaction

Before the calcine impoundment area could be capped, additional material was required to fill the area, the material required compaction and the area had to be shaped for proper drainage. In October 2000, calcine from Evergreen Resources, previously originating from the vanadium plant was placed in the calcine impoundment area in a series of 2-foot lifts. Four lifts were placed and each lift was tested for compaction in at least 8 locations. If a section of a lift did not meet the compaction specifications, steps such as adding water and additional compaction were taken and the density was re-tested. This process was repeated until the compaction met the specifications of the project.

Beginning in May 2001 the roaster reject and off-spec fertilizer was placed in the calcine impoundment area. These materials were placed in the calcine impoundment area in 9 2-foot lifts. Each lift was tested for compaction in at least 8 locations. If the testing indicated that the density at a particular location was smaller than the project specification, additional water and/or compaction was done. This was repeated until the areas met the compaction requirements of the project.

The surface of the calcine impoundment area was shaped to provide the proper drainage. The final surface was surveyed to provide the basis elevations for the as-built drawings. The surface was then smooth rolled in preparation of the 40-mil LLDPE placement. The liner contractor accepted the final grade of the calcine impoundment area. The signed acceptance forms were reviewed and are located in the completion report (GET, 2002).

40-mil LLDPE FMC Material Placement

The LLDPE material was logged in by the CQA inspection engineer when it was delivered. The lot number, roll number, date of delivery and any damage was noted on the material log. Certificates of analysis were received for each lot of material. The certificates of analysis were reviewed and the material that was received met the specifications of the project.

The liner contactor placed 131 LLDPE panels over the calcine impoundment area. The panels were placed in a north-south direction. Each panel was logged on the panel placement form that contained the panel and roll number, panel length and width and the date the panel was installed.

The quality assurance program for the LLDPE placement included testing for peel and shear strength by an outside laboratory. A total of 96 destructive test samples were collected and sent to the outside lab for testing. In all cases the peel and shear strength results exceeded the minimum peel and shear strengths required for this project. All repairs made to the LLDPE were completed according to the project requirements.

Geocomposite Drainage Layer Placement

The geocomposite material was logged in by the CQA inspection engineer when it was delivered. The lot number, roll number, date of delivery and any damage was noted on the material log. Certificates of analysis were received for each lot of material. The certificates of analysis were reviewed and the material that was received met the specifications of the project.

The liner contactor placed 469 geocomposite panels over the 40-mil LLDPE that was placed earlier in the project. The panels were placed in a north-south direction on the north and south portions of the calcine impoundment area and the panels were placed in an east-west direction in the central portion of the impoundment area. Each panel was logged on the panel placement form that contained the panel and roll number, panel length and width and the date the panel was installed.

The quality assurance program for the geocomposite material placement included testing for peel adhesion strength by an outside laboratory. A total of 78 destructive test samples were collected and sent to the outside lab for testing. In all cases the peel adhesion strength results exceeded the minimum peel adhesion strength required for this project.

Soil Cover Placement

The soil cover was placed on the geocomposite in two stages. The first stage was to place a nominal 2-foot layer of subsoil on the geocomposite. The documentation indicates that the soil was pushed onto the geocomposite using dozers and that there was no direct dumping of subsoil on the geocomposite. The thickness of the subsoil placement was measured by the earthwork contractor on a continuous basis during the placement operation.

The second phase of the soil cover placement was to place a nominal 1-foot layer of topsoil on top of the subsoil layer. The topsoil layer was pushed over the subsoil layer by dozers. To avoid compaction trucks were not allowed to drive on the topsoil layer. The thickness of the topsoil was measured by the earthwork contractor during the placement operation. The topsoil layer was smoothed in preparation of fertilizing and seeding the cap.

Vegetation Seeding and Fence Installation

The completion report indicates that the smoothed surface of the cap was seeded in the fall of 2001. The 2008 inspection showed that the vegetation on the cap was predominately wheat grass. This is the species that was planted following construction.

The design called for a chain-link fence surrounding the cap. The 2008 inspection showed that his fence is in good condition and that the gates are locked.

Regulatory Agency Oversight

Prior to construction the cap design was approved by the US EPA Region X. Oversight during the construction of the cap was provided by Carl Kitz of EPA. Mr. Kitz made several trips to the site during the construction. When the construction of the cap was nearing completion EPA sent an engineering representative from Ecology & Environment to review the project.

A pre-final inspection of the calcine cap was conducted on July 18, 2001. Present at the inspection was Neil Thompson and Carl Kitz of EPA and representative from Kerr-

McGee. Following this inspection EPA agreed that the construction was complete and that the final inspection would take place in 2002. The final inspection was part of the 5-year review that took place in June 2002.

Conclusions

Based on the review the information contained in the referenced documents, all aspects of the calcine cap construction were completed as designed.

4.2.6 MAP Ponds

The MAP ponds (solids and liquids) were sampled during the RI. Three MAP samples were collected from two separate MAP ponds. COC metals in the MAP ponds included molybdenum (832 ug/l) and 10,100 ug/l of vanadium.

Analysis of the MAP solids indicated pH values of 6.3 to 6.6 units. Analysis of metals concentration indicates concentrations had a wide range of vanadium (621 to 10,400 mg/kg). However, molybdenum concentrations were relatively small (2.7 to 141 mg/kg). Concentrations for manganese were small and ranged from 20.9 to 59.5 mg/kg. Figure 1-6 shows that only one boring (B-6) penetrated the MAP pond area, with bedrock occurring at 10 feet. It is likely that the MAP ponds rested directly on bedrock while operational based on this boring. The MAP ponds were eliminated in 1993 during the RI. As the result of the elimination of these ponds, no additional actions were taken for this site during the FS nor were any actions required by the ROD. The current level of information does not allow for the assessment impact from these former facilities to ground water.

The inspection of the uncapped MAP pond area was conducted September 18, 2008. After a brief reconnaissance of the area, the inspection grid was established as previously described and described in Appendix A. Details of the inspection are presented on Figure 4-6. The field engineer walked the grid along the east-west and north-south lines. Where the field engineer observed areas of erosion, evidence of burrowing animals, deep tap-rooted plants or areas standing water that may have been present, the area was located using the hand-held GPS and a photograph of the area was taken. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

The MAP pond area is covered with vegetation that is mainly wheat grass and other grasses. No deep tap-rooted plants were observed during the inspection. No evidence of burrowing animals was observed during the inspection. The eastern portion of the former pond area is covered by fill material. There is a relatively large low area to the west of the fill area that showed signs of standing runoff water. Erosion is evident along the northern and southern boundaries where storm water from the plant area flows to the west. There is evidence that some of this storm water runs onto the MAP pond area.

4.2.7 Former Vanadium Plant

No investigation was competed in the vicinity of the vanadium plant during the RI, or following that time. The vanadium plant was removed in 2002, leaving only the foundation exposed in a few locations. The area was covered with limestone fines and sloped to provide positive drainage away from the foundations.

The inspection of the vanadium plant was conducted August 9, 2008. After a brief reconnaissance of the area, the inspection grid was established as previously described and described in Appendix A. Following the establishment of the grid, the field engineer walked the grid along the east-west and north-south lines. Where the field engineer observed areas of erosion, evidence of burrowing animals, deep tap-rooted plants or areas standing water may have been present, the area was located using the hand-held GPS and a photograph of the area was taken. The photo log of the inspection that includes the photographs, latitude and longitude coordinates and a brief description of the problem are attached in Appendix A.

The former vanadium plant foundation is currently covered in most locations with fine limestone and no vegetation was observed. No evidence of burrowing animals was observed. Several areas that showed evidence of standing water are present in the inspection area on the vanadium plant footprint cover. There are several areas where the concrete foundations from the vanadium plant are exposed through the cover material. This could be a conduit for infiltration of storm water. The former plant area and cover is relatively flat and no storm water runoff direction could be determined.

4.2.8 Boiler Blowdown Scrubber Pond

The boiler blowdown pond covers a former scrubber pond that is about an acre in size based on Figure 1-4. The roaster scrubber solids were impounded west of the vanadium plant for about 10 years until a new pond was opened south of the calcine that is now capped. The mineralized water resulting from water softener regeneration and blow-down of the boilers was contained in this original roaster scrubber pond. This material was discharged to the pond since the plant became operational, but this pond was abandoned, covered, and seeded during 1992.

Three samples were collected from boiler blowdown pond solids (BBP-1, BBP-2, and BBP) during the RI. Analytical results indicate that pH ranged from 7.0 to 9.2. Total metals concentrations of note included chromium (1,330 to 2,530 mg/kg), copper (1,360 to 2,720 mg/kg), iron (22,700 to 39,600 mg/kg), nickel (632 to 1,010 mg/kg), manganese (232 to 248 mg/kg), molybdenum (86.3 to 116 mg/kg), zinc (296 to 330 mg/kg) and vanadium (2,750 to 3,920 mg/kg).

Review of the lysimeter data from the RI indicated that deeper lysimeter L-4 (completed in soil) and shallow L-5 (completed in the scrubber solids beneath the boiler blowdown pond) were installed in boring B-5. The boiler blowdown scrubber pond cover was described as covered with a sparse to thin grass cover. Molybdenum concentrations were smaller in deeper lysimeter L-4 (0.1 to 1 mg/l) than in shallow lysimeter L-5 (0.6 to

2.2 mg/l), but the decrease in concentration did not appear to be significant in the underlying soils. Vanadium concentrations actually increased by an order of magnitude with depth from about 0.05 to 0.2 mg/l in shallow lysimeter L-5 to about 0.5 to 1.6 mg/l in deep lysimeter L-4. Therefore, the observed metal concentrations in deep lysimeter L-4 are likely to best represent leachate that could reach ground water from this area. No actions were taken for this site during the FS or in the ROD.

4.2.9 West Calcine

Calcine from the early operation of the facility (1963 through 1972) was impounded on the west side of the facility as shown on Figures 1-3 and 1-4. This impoundment was loosely covered with native soil ranging in thickness from about 6 inches to 5 feet and seeded after the calcine impoundment area was moved to the east side of the facility in 1972. This impoundment area covers approximately 13 to 17 acres, although the exact boundary is not delineated. The approximate area is shown on Figure 4-8. This area was investigated in 1992 during the RI through a series of borings (B-1 through B-4 locations shown on Figure 1-5) and by installing a lysimeter in the calcine and in the soil below the calcine in one boring (B-1). Data indicate that the calcine rests on bedrock in at least one location.

Review of the RI lysimeter data indicated that molybdenum and vanadium concentrations were larger (by three orders of magnitude) in the shallow lysimeter (in the calcine) than in the deeper lysimeter (L-1). Deep lysimeter L-1 was completed at about 10.5 feet in native soil and shallow lysimeter L-2 was completed in covered calcine tailings, as shown on Figure 4-7. RI data indicated that molybdenum concentrations in deep lysimeter L-1 were about 0.1 mg/l, in comparison with about 195 mg/l in shallow lysimeter L-2. Reported vanadium concentrations were about 0.06 mg/l in lysimeter L-1 versus about 34 to 46 mg/l in shallow lysimeter L-2. Shallow lysimeter L-2 did not yield any water prior to June of 1993, although the deeper lysimeter L-1 yielded samples in 1992 and 1993. The RI concluded that the apparent correlation of poor water recovery and large metal concentrations in the shallow lysimeter compared with good water recovery and small metals concentrations in the deep lysimeter indicate that: 1) metals were concentrated by evapotranspiration in the upper soil horizon; 2) metals in the soil water were adsorbed or exchanged with the native soils beneath the sources; and 3) metal concentrations in the deep lysimeters were more representative of the character of leachate that could reach ground water in this area. However, there are known locations where calcine rests directly on bedrock, negating the mitigating effects of metal ion exchange in soil.

4.2.10 RI/FS Ground Water Model Review

Ground water modeling was performed in a comparative analysis of ground water remedial action alternatives as part of the RI/FS (Dames & Moore, 1995b). The goals of the modeling evaluation were to address the following questions:

1. What magnitude of decrease in the concentrations of the six COC would be expected over time when liquid sources were eliminated, and;
2. Would the magnitude of the decrease in COC concentrations be significantly increased over time if liquid source elimination (LSE) was supplemented by ground water extraction.

Answers to these questions were used to select a remedial action alternative for the site. Several combinations of ground water remedial alternatives were evaluated ranging from no action to LSE with multiple extraction wells. Caveats listed for the model predictions were that the model was calibrated to within an order of magnitude of observed COC concentrations and should be considered reliable within that range of values. Even more specifically, a list of what the model was not intended to do includes: evaluate the extent of contamination, simulate specific flow paths, simulate the exact pattern of flow, or predict the precise future concentrations at specific downgradient locations.

Based on the modeling results, the proposed remedial action alternative was LSE with additional solid source remedial actions, including excavation and on-site disposal of S-

X and scrubber pond solids, and reuse/recovery of the calcine tailings. With respect to question 1 (what magnitude of decrease in the concentrations of the six COC would be expected over time when liquid sources were eliminated), the magnitude of decrease over time for this alternative was predicted to meet and decrease below risk-based concentrations or maximum contaminant levels within five years (see caveats and limitations listed above). With respect to question 2, (would the magnitude of the decrease in COC concentrations be significantly increased over time if liquid source elimination (LSE) was supplemented by ground water extraction) no additional ground water extraction was required because extraction did not substantially change the results.

A one-layer, two-dimensional model was constructed using the USGS MODFLOW program to simulate ground water flow in the shallow aquifer covering an area of about 3.5 square miles (model domain). The model domain was oriented in the general direction of ground water flow (southwest) with the plant facility placed near the center. Chemical transport was simulated using the MT3D software package integrated with the MODFLOW program. Backward modeling was used to simulate ground water flow and contaminant transport between 1963 (plant startup) and 1995 (predicted date when remedy would be in place). Model output was calibrated to November 1992 ground water flow patterns and May 1993 chemical concentrations. The calibrated model was then used as the basis for simulating a 30-year period of ground water flow and transport, referred to as the forward model (between 1995 and 2025), with individual model runs used to predict changes in concentrations under the varying conditions of the proposed remedial alternatives.

In the backward model COC entered the model through 1) recharge from direct seepage from the ponds, and 2) infiltration of precipitation which leached COC from solid sources. In the forward model, for alternatives with LSE, all pond seepage stopped. After LSE, the only source of COC assumed in the model was leachate generated when precipitation infiltrated through the solid sources.

Basic flow model and transport assumptions and limitations included:

- Ground water movement in the saturated basalts and interflow sequences responded in a manner similar to one hydrostratigraphic unit that responded similar to unconsolidated aquifer materials.

- The Salt Lake Formation underling the basalts did not contribute to the ground water in the basalts and could be modeled as an impermeable barrier.

- Mixing of seepage from the liquid sources and leachate from the solid sources occurred immediately through the entire saturated thickness of the aquifer.

- Four Monsanto production wells and one on-site production well (PW-10) were operated between 1963 and 1995 and were assumed to remain in operation throughout 2025. The rate of pumping of PW-10 was 350 gpm. The Monsanto wells were pumped at rates of 0.5, 500, 2,000, and 2,080 gpm. The wells were assumed to be fully penetrating in the shallow aquifer.

- The Hydrologic Evaluation of Landfill Performance (HELP) model was used to predict infiltration rates. The runoff fraction was set to zero because snowmelt and precipitation had not been noted to leave the active calcine tailings area in the form of runoff.

- Process-water and lysimeter-water analytical data were representative of initial concentrations for pond liquids and solid source leachates. (Some source concentrations were increased in the model to achieve better calibration.)

- Mass was accumulated in the model by adsorption to the aquifer matrix. Mass left the model through constant head boundaries and pumping wells.

- A global mass balance approach provided initial estimates of adsorption coefficients (Kd). (During modeling initial Kd values were slightly adjusted to improve calibration.)

In the discussion of the model in the Comparative Analysis Report (Dames & Moore, 1995b), efforts were made to apply an overall conservative approach by using conservative model assumptions and conservative input values. Three examples of conservative model input values that were mentioned included: 1) using a smaller saturated thickness (100 feet instead of 200 feet) to reduce dilution and increase predicted concentrations downgradient, 2) using largest observed concentrations from a source area as representative of the entire area to increase predicted concentrations during forward modeling, and 3) using a higher infiltration rate (1 inch/year) to allow for greater mass of COC to be leached from the solid sources and transported to the ground water. Sensitivity analysis showed that the most sensitive input parameters to the model were aquifer thickness, infiltration, and solid source leachate concentration.

In 2008, 13 years post-modeling, actual ground water concentrations remain larger than predicted. Although most wells show decreasing COC concentrations trends over time, not all wells demonstrate decreasing trends. Changes in timing of remedial events, remedy options, and site conditions compared with those used in the model all had an effect on the current conditions. Upon review of the 2008 inspection and review of site conditions since the RI/FS and ROD, some of the modeling input parameters may have had a more profound influence on the predicted outcome.

Changes in timing of remedial events and remedy options include:

- LSE with excavation and on-site disposal of S-X and scrubber pond solids was completed in 1997, 2 years after the 1995 modeling date.

- The reuse/recovery of the calcine tailings was not effective and the FS was modified to include capping of the calcine tailings in place, which was completed in 2001, 6 years after the 1995 modeling date and four years after LSE, delaying the effects of LSE by providing a significant on-going solid source COC contribution to ground water prior to capping.

- The model assumed that the S-X ponds and scrubber ponds would have no infiltration after closure. The S-X and scrubber ponds did not have impermeable caps and would have infiltration and leaching after closure. Wells near the former S-X ponds have the largest concentrations of COC. Results of the 2008 inspections indicate water is collecting on these covers and promoting infiltration.

- The infiltration estimate assumed no runoff from the active calcine tailing (this was prior to capping because capping had not been selected during the FS). The capped calcine area has snow buildup and run off which is partially diverted to an infiltration basin, but also ponds near and on the former scrubber pond cover.

- Ponded water is present during the spring around the former scrubber pond and on the S-X pond.

- On site production well PW-10 was no longer used for process water after 2000; limited pumping occurs in the summer for irrigation of landscaped areas.

- Adsorption coefficients for the metals were estimated at very low values compared to literature values. Vanadium has a published value of 1,000 ml/g (Table A-1 of the Ground Water Modeling Report in the KMCC RI/FS), which is also the default valued used in the MAROS program, compared to 0.16 ml/g used in the model. Molybdenum has a published range from 0.4 to 4,000 ml/g from one source and a more limited range of 9 to 125 ml/g from other sources (Table A-1 listed above), compared to 0.31 used in the model. The default in the MAROS program for molybdenum is a Kd of 20 ml/g. Sensitivity ranges were also very low (0.08 and 0.32 ml/g for vanadium) when evaluated and the conclusion was made that Kd had low sensitivity in the modeling results.

- The effective porosity of 0.08 used in the model and 0.1 used to estimate the mass of COC adsorbed to the aquifer is low. By increasing porosity and adsorption, more mass is present in the model. In the sensitivity analysis only porosity was increased substantially (to 0.25 or 25 percent) and the result was increased predicted vanadium concentrations downgradient from the KMCC site at 5 years, but not a noticeable difference at 10, 20, or 30 years. The increase in porosity and not adsorption (less mass) essentially flushed the vanadium out of the model.

- The forced application of 100 feet for aquifer thickness to calibrate the transport model could be compensated by increasing porosity, infiltration, and leachate concentration. The reduction of aquifer thickness to 100 feet was done to achieve better agreement between predicted and observed/reported COC concentrations in on-site monitor wells and to match drawdown in Monsanto production wells.

- The Monsanto wells are screened from 190-255 feet, pulling from the bottom of the basalts. This deep pumping may explain the vertical downward gradient between paired wells.

4.2.11 Ground Water Levels and COC Concentration Changes

Previously in this evaluation, the correlation between annular increasing and decreasing precipitation rates was shown to have both immediate and long-term influence to rising and falling water level elevations at the site. Increasing COC concentrations noted at several wells following the winter of 2004-2005 are in part observed to correlate with rising water levels in the aquifer following years of drought and lowered water levels. Some of this apparent correlation could be caused by changes in precipitation in general rather than changes in water levels as demonstrated by the correlation between precipitation and water levels. However, seasonal COC concentration fluctuation trends are suggested at a number of site well locations, including wells KM-2, KM-3, KM-6, KM-8, KM-15, KM-16 and KM-18. Figures C-1 through C-27 in Appendix C present the relationship between seasonal changes in COC and changes in the water levels. Evaluations of these charts indicate the following:

- KM-2 – Molybdenum concentrations continue to decrease over time and are unaffected by the rising ground water level trends after 2004. Vanadium is seasonal and concentrations flatten out after 2004. Capping of the calcine does not appear to have affected COC concentrations in this well. Seasonal Kendall results suggest a strong seasonal trend for vanadium.

- KM-3 - Manganese concentrations do not appear seasonal nor appear affected by the cap construction. Molybdenum concentrations became seasonal after 2001 and flattened out, indicating a potential influence from the cap shedding water to the scrubber pond cover. Vanadium does not appear as seasonal as the other wells and concentrations show substantial concentration variance after 2003 when annual moisture increased.

- KM-4 – The decline in molybdenum concentration slowed considerably after 2001, but concentrations continued to fall over time and are unaffected by the rising ground water level trends after 2004. Vanadium does not appear as seasonal as the other wells and concentrations flattened after 2001, but appear to increase with the rising ground water level trends after 2004.

- KM-5 – Molybdenum concentrations appear seasonal and declined below the RBC, but concentrations were affected by the rising ground water level trends after 2004. Vanadium is seasonal and concentrations correlate with the rising ground water level trends after 2004. Seasonal Kendall results suggest a strong seasonal trend for vanadium.

- KM-7 – Molybdenum concentrations appear seasonal with the larger concentrations occurring in the fall (lower water levels) through 2003. Following 2004, the molybdenum concentrations declined. Vanadium is seasonal and concentrations appear opposed to molybdenum but correlate with the rising ground water level trends after 2004.

- KM-8 - Manganese concentrations appear seasonal and correlate with the changes in the water levels in this well and with annular trends in precipitation. Molybdenum concentrations were seasonal prior to the drought in 2001 but were less seasonal through the drought until 2004. Molybdenum concentrations bottomed out in 2006. Vanadium concentrations are inverse to the water level trends. As water levels fell in this well between 2000 and 2005, vanadium concentrations increased. Vanadium concentrations fell after 2004 during rising water level elevations. Increased vanadium is correlated with increased salinity and decreased head.

- KM-9 - Vanadium seasonality is subtle and concentrations continue to decline and appear unaffected by the increased moisture after 2004.

- KM-15 - Molybdenum concentrations do not appear seasonal, continue to fall over time and are unaffected by the rising ground water level trends after 2004. Vanadium is very seasonal and concentrations continue to decline and appear unaffected by the increased moisture after 2004, with an exception of a spike in 2005. Seasonal Kendall results suggest a strong seasonal trend for vanadium.

- KM-17- Molybdenum concentrations do not appear seasonal, and appear to decline after capping of the calcine in 2001.

- KM-18 - Molybdenum concentrations do not appear seasonal, continue to fall over time and are unaffected by the rising ground water level trends after 2004. Vanadium is not as seasonal in this well as the nested shallow counterpart KM-15. Concentrations continue to decline and appear unaffected by the increased moisture after 2004.

- Wells KM-6 and KM-16 suggest consistent COC ground water concentration changes seasonally when compared with changes in ground water levels and overall annual changes in moisture. These seasonal effects are notable between 2001 and in 2005 for molybdenum and vanadium, but seasonal effects for manganese are still observed to a smaller degree. Increasing COC in wells KM-6 and KM-16 following 2004 appear correlative to rising water levels in the aquifer following years of drought. Wells KM-6 and KM-16 are centrally positioned within the larger hydraulic conductivity areas directing larger concentrations of COC to be transported in a southwesterly direction. Both wells indicate seasonal fluctuations and demonstrate a delayed response to LSE in 1997. The delayed response may be due to the increased distance to these well locations. Seasonal Kendall results suggest a moderate to strong seasonal trend for vanadium in these wells.

These observations of increasing annular moisture and increased concentrations in a number of the wells, and noted increases in the spring following snowmelt suggests that former source areas, most notably those of the former S-X and scrubber ponds may be contributing to COC in ground water on the site and downgradient of the site.

4.2.12 Institutional Controls

The Consent Decree required that institutional controls be placed on the industrial site and the private property to the south of the site. The Consent Decree required that these institutional controls must be protective of human health and the environment and allow EPA and its contractors access to the property. The institutional controls at the facility include deed restriction on the former Hopkins property immediately to the south of the Tronox facility. This land was purchased by Tronox in 2004 and the deed restrictions are still in place. This control appears to be adequate.

The Consent Decree requires that Tronox implement controls that will not allow the consumption of ground water except for the treating and monitoring of ground water contamination and no use or activity will disturb any remedial actions that have been taken. An additional requirement of the Consent Decree is that any monitor wells installed to treat or monitor ground water contamination will be installed according to approved work plans. These requirements are consistent with the requirements of the Proprietary Controls (EPA, 2000) described in the referenced guidance document.

The site has remained an industrial site the entire time since the Consent Decree was signed. The facility is connected to the City of Soda Springs public water supply. Tronox uses City water or bottled water for all domestic purposes. The facility has not prepared a document that details the water use requirements or established any easements or other Proprietary Controls that are attached to the chain of title to restrict land use in the future. This has not been completed because it was not anticipated that the property would be out of the control of Kerr-McGee or its successors and the property would remain an industrial facility for the foreseeable future. These controls have been effective in the past, but establishing documented Proprietary Controls within the chain of title may be required in the future.

Although physical barrier to limit access to the site are not considered institutional controls by the guidance document, Tronox has installed and maintained several barriers to access by the general public. Access to the facility is limited to individuals that are employed by the facility or approved vendors. These individuals must pass through a card key operated gate to gain access to the facility. Access to the on-site landfill and calcine cap is further restricted because both facilities are surrounded by a security fence and the gates are locked. Only authorized individuals have access to the keys that open the gates. These controls appear to be adequate to protect the general public.

It has been the facility's policy to allow State or Federal agencies, or their contractors, access to the facility to conduct specific tasks. The facility has a documented policy describing the actions to be taken if State or Federal agency personnel arrive at the facility for an unannounced visit. This policy has been used in the past and it has worked well. However, most visits by State or Federal agencies are planned in advance and access to the facility is part of the planning process.

In 1996 Tronox (Kerr-McGee Chemical at the time) negotiated an easement with land owner. This easement was attached to the chain of title by recording it with the Caribou County Clerk. This easement is considered a Proprietary Control by the guidance document. The easement contains an affirmative easement that allow access to the property by Tronox or its contractors and State or Federal agencies or its contractors and a negative easement because it restricts the development of ground water beneath the property until the concentration of the ground water beneath the property becomes smaller than the risk-based concentrations. This land was purchased by Tronox in 2004 and the easement is still attached to the chain of title. This control appears to be adequate and meets the requirements of the guidance.

The risk assessment that was completed for the site included a potential future residential scenario. This future resident was located near the southern border of the site. In order to address the potential risk of a future resident in this area, the Consent Decree required that institutional controls be established to prevent the exposure to contaminated ground water. It has been the understanding of Tronox that the Consent

Decree only required institutional controls be established for the property immediately south of and adjacent to the site. Even though Tronox did not think that additional controls were required by the Consent Decree, Tronox contacted the City of Soda Springs to determine what controls the were in place to prevent the development of ground water for beneficial uses within the City limits. The City stated that they required building permits and hooking up to the City water supply if any development were to occur. This control meets the Governmental Controls requirements found in the reference guidance document. This control does not appear to be adequate because Tronox has recently learned that anybody could obtain a drilling permit for a domestic well form the Idaho Department of Water Resources without going through the City of Soda Springs. However, this does not appear to be a large risk because there has been no development in the last 10 years and any future development is unlikely.

Another factor that should be considered is the COC concentrations at Finch Spring and Big Spring. The vanadium concentration in both of these springs is smaller than the risk-based concentration and the molybdenum concentration at these springs is falling to near the risk-based concentration. Analysis presented in this document suggests that molybdenum may be below the RBC at Finch Spring in 2009. Institutional controls in this area (to the south of the site on uncontrolled property) should not be required once the water quality in these springs falls below the risk-based concentrations.

5.0 GROUND and SURFACE WATER QUALITY TREND EVALUATION

5.1 General

In order to evaluate the continued effects and performance of the LSE to ground and surface water impacts, existing semiannual data were reviewed as stated in the work plan. The purpose of the trend evaluation is to assess the likelihood of the remedy achieving cleanup goals within a specifiable timeframe, as stated in the Addendum I work plan. To achieve this end, ground and surface water COC data (specifically molybdenum and vanadium) were evaluated following cessation of uncontrolled waste stream discharges (October 1997) to estimate the relative change in ground water COC concentrations that resulted from LSE. The calcine was not capped until approximately 4 years after LSE, so effects of the infiltration and ponding in the calcine affected some of the early time COC ground water concentration data for some of the wells, including wells KM-2, KM-3 and KM-4. Methods used to evaluate the data include the Mann-Kendall analysis (presented in Appendix B), graphical interpretation of the normalized data (monitor well network evaluation report) and regression analyses that are discussed in this section with the regression curves, regression equations and coefficients presented in Appendix C.

Existing data collected as part of the monitoring program were evaluated using regression analysis, and using the Mann-Kendall statistic (Appendix B) to evaluate the same data sets. Two data sets were evaluated as part of this task. The first data set included vanadium and molybdenum data from November 1997 to the most recently validated data (May 2008), the period following the implementation of the remedial actions. This truncation was prepared to focus the evaluation on the trends following the implementation of the remedial actions. The second set of data includes vanadium and molybdenum data results from a shorter period of time (May 2004 through May 2008). These data were evaluated in conjunction with the November 1997 through May 2008 data set to assess whether the more recent data set demonstrate trends that are notably different from the overall LSE time period. These evaluations were done for most interior monitor wells, for each point of compliance monitor well, and for Finch Spring and Big Spring. The purpose of this evaluation was to estimate when cleanup performance standards can reasonably be expected to be met, one of the questions posed by the Addendum I SOW.

5.2 Regression Analysis

An analysis using the November 1997 through May 2008 and the May 2004 through May 2008 data sets provide an estimate when these concentrations may potentially fall below their respective RBC for molybdenum and vanadium. TBP and TPH are assumed to be less than the RBC for all wells except KM-8, and therefore are not considered in this analysis.

Arsenic was detected during the RI in the limestone settling ponds at a concentration of 190 ug/l with much smaller concentrations in the MAP (14.7 ug/l) and scrubber pond (8 ug/l). Arsenic, frequently found to be less than detection in most wells after 1999 is not evaluated. There is no clear trend for arsenic in well KM-8, or in the wells (KM-2, KM-3 and KM-4) surrounding the covered scrubber pond where arsenic concentrations are close to the RBC. Well KM-8 demonstrates the largest ground water concentration; therefore, prediction of the time for arsenic concentrations in ground water to fall below the RBC is uncertain.

Manganese is evaluated only for well KM-8 because well KM-3 demonstrates increasing manganese concentrations in ground water with time. The remaining wells demonstrate that manganese concentrations in the ground water are currently at or less than the RBC.

Projected concentration decay trends are estimated where possible, using a regression trend curve fitted to the real-time monitoring data from ground water where the COC currently exceed the risk-based concentrations of vanadium and molybdenum. These two COC were selected because most of the risk in ground water is driven by the occurrence of these metals. The time period for data used to evaluate the projected COC trends included the period from November 1997 (the first round of ground water collected from the monitoring points following LSE) through the May 2008 round.

Data analyzed to predict future trends include ground water results obtained from wells KM-2, KM-3, KM-5, KM-6, KM-8, KM-9, KM-12 and KM-13 that are located on the vanadium plant site; and off-site wells KM-15, KM-16, KM-17 and KM-18 that are located south of the site. Analysis for Finch and Big Spring molybdenum trends are also presented. Results of the regression analysis presented in Appendix C. Results of the predictions based on the 1997 to 2008 data are summarized in Table 5-1. Predictions for COC based on the 2004 to 2008 data set are summarized in Table 5-2.

Most of the wells, both on and off the industrial site and the springs demonstrate decreasing concentrations with respect to molybdenum and vanadium based on the data from the 10-year LSE evaluated period. However, as the result of increasing concentration trends between 2004 and 2006 in ground water downgradient of the former scrubber and S-X ponds, the estimated time to reach the RBC can not be reliably predicted. The wells that appear somewhat uncertain to reach the RBC following LSE include wells KM-2, KM-3 and KM-4 that surround the former scrubber pond, and wells KM-6, KM-8, KM-15 and KM-16 that are south and downgradient of the covered S-X pond basin and the site. Well KM-5 located near the former MAP ponds has achieved molybdenum cleanup levels, but the period to achieve the vanadium RBC will be substantially greater.

Analysis of 2004 to 2008 vanadium data from this group of wells shown in Table 5-2 indicates that the time to reach the RBC could be substantially longer than the estimated times from the 10-year data set. Conversely, estimated trends based on the most recent four years of data for a few wells suggest that the rate of COC decrease is occurring more quickly when compared with the full 10-year LSE period (November 1997 to 2008). The 2004 to 2008 data set, for the most part, show decreasing trends in COC at a rate that is slower than immediately following LSE. However, the results from the regression analysis of the 2004 to 2008 data should not be relied upon for prediction of time to reach the RBC in ground water. These data implicate COC mass loading to the aquifer in the absence of pond sources during this time period.

COC concentration trends with time and projected trends for these wells are presented in Figures C-28 through C-50 in Appendix C. Projected trends are based on the post-LSE monitoring period data. The projected period into the future varies between wells in order to demonstrate the approximate time when the COC fall below the RBC.

5.2.1 Analytical Method

Existing ground water data were evaluated using a statistical forecast function for exponential decay. A forecast calculates or predicts a future value by using existing values. The predicted value is a y-value (future concentration of a COC in ground water) for a given future date. The known values are ground water data from the wells. A forecast statistically predicts future values based on a regression function of a range of known data or known x- and y-arrays. Regression analysis estimates the relationship between variables, so that a given variable can be predicted from one or more other variables.

Data curves for the ground water concentrations shown in Appendix C were generated using an exponential function that describes decay of a substance and calculates the least squares fit through points by using the equation:

$y = ce^{-kt}$

where:

e is the base of the natural logarithm;

c is a constant at y_0 (initial concentration) at $t = 0$, and;

$^{-kt}$ is a constant for the predicted time, with the minus sign representing decay of concentration with time.

A trend line and the equation for that trend line are generated for the data set based on known x-values for the best-fit curve. The y intercept for the regression trendline is set at zero. This is appropriate, based on the observed absence of manganese, molybdenum and vanadium concentrations in background ground water quality data.

5.2.2 Results of Trendline Analysis

Results of the trendline analysis are presented on Figures C-28 through C-50 in Appendix C. It is possible that future ground water concentration trends may differ from results generated using the two data sets.

The minimum range of each graph has been set at the respective RBC. Analysis of the forecast trends suggests the following from the November 1997 to May 2008 data set:

- Monitor wells that appear somewhat uncertain to reach the RBC following LSE include wells KM-2, KM-3 and KM-4 that surround the former scrubber pond, and wells KM-6, KM-8, KM-15 and KM-16 that are south and downgradient of the covered S-X pond basin and the site.

- Wells KM-5 and KM-9 were reduced to the RBC for molybdenum in 2003 as predicted by use of these trendlines. However, a spike in molybdenum in the ground water between 2003 and 2007 affected both wells. Both well KM-5 and KM-9 results in May 2008 indicate that the molybdenum concentrations are below the RBC.

- Molybdenum concentrations will continue to decline in most wells in response to LSE and reclamation. However, wells downgradient of the former S-X and scrubber pond will have molybdenum concentrations exceeding the RBC well beyond 2015.

- On-site wells and several off-site wells are forecast to exceed the vanadium RBC for a period of twenty years or greater following remedial actions completed in 1997. Based on current trends, wells KM-9 and KM-13 are the first wells expected to fall below the vanadium RBC. Monitor wells located downgradient of the former S-X and scrubber pond will have vanadium concentrations exceeding the RBC far beyond 2020 based on current trends.

- Manganese is estimated to potentially exceed the RBC for more than 40 years following LSE in well KM-8, in part as the result of a rising manganese trend since 2004. Well KM-3 will exceed the manganese RBC for an uncertain period because a decreasing trend can not be predicted from the data. The rising manganese trend in well KM-3 is not occurring in other wells monitoring the covered scrubber pond area.

5.3 MAROS Evaluation

The purpose of completing the MAROS evaluation (presented in Appendix B) was to assess the adequacy of the Tronox monitoring network in characterizing the migration of COC. To prepare for the evaluation the existing monitoring program was documented, the ground water modeling for the RI was critically reviewed, and the CSM was updated to reflect current understanding of site hydrogeologic conditions and transport processes. This preliminary evaluation was used to define and justify hydrogeologic input parameters and physical site parameters used in the program. The details and dynamics of the complex hydrogeologic system and contaminant transport processes had to be simplified to accommodate the two- and three-dimensional statistical and analytical calculations. The two main COCs at the site, molybdenum and vanadium, were used to represent contaminant trends in the evaluation. The MAROS program provided the following:

- Plume analysis;
- Spatial moment analysis;
- MAROS preliminary evaluation;
- Optimization for sampling location and frequency, and;
- MAROS data sufficiency analysis of cleanup by individual well and site.

Results from the plume analysis and spatial moment analysis presented in Appendix B indicate that both molybdenum and vanadium plumes have decreased since LSE was performed in 1997. Concentrations in most wells show a decreasing trend with few exceptions. Recent data, within the past five years, reflect a slower rate of change, with some wells reaching a flat slope showing no trend or even a slightly increasing trend. Both the plume and spatial moment analysis illustrate that molybdenum and vanadium have different reactions and migration patterns in the subsurface. Spatial and temporal variations can be attributed to natural variability inherent in any complex subsurface system. Physical changes in plant operations and movement of solid sources to different site locations have likely resulted in some small changes in trends in the data. However, the statistical evaluation shows a high degree of confidence in the overall trend designations.

The MAROS preliminary evaluation of the monitoring program (presented in Appendix B) suggests that the decreasing trends in molybdenum and vanadium could indicate a decrease in sampling duration and frequency is justified. The optimization of sampling location and frequency concluded that all sampling locations are valid but sampling frequency can possibly be reduced in many wells. The reduction in frequency to annual and biennial in some wells and an increase to quarterly in others (KM-4 and KM-8) was based on individual COCs and is not practical to implement. However, sensitive wells were identified that require attentive data evaluation. The MAROS data sufficiency analysis of cleanup by well and site confirmed that cleanup has not been attained and may take several years to achieve.

6.0 CONCLUSIONS

The second five year review for the Kerr-McGee Superfund Site was completed in September 2007. The five year review found that the remedies were constructed in accordance with the requirements of the ROD. However, a protectiveness determination of the remedy was not made because levels of COC in ground water and surface water remain above cleanup goals. EPA concluded that COC concentration trends, after initially decreasing in ground water following LSE implementation in late 1997 became relatively flat-trending since the late 1990s and linger above risk-based cleanup goals identified in the ROD. EPA noted that in some cases, trends for certain COC at specific monitoring wells were increasing over the past several years. Ground and surface water data in October 2008 indicate that ground water clean-up goals had been met for arsenic in all but two wells (KM-2, KM-8), clean-up goals had been met for tributyl phosphate in all but one well (KM-8), clean-up goals had been met for manganese in all but two wells (KM-3 and KM-8), and clean-up goals had been met for TPH in all wells except one well (KM-8). Vanadium and molybdenum remain dispersed in the ground water aquifer beyond the property boundaries in 2008.

As the result of all of the ground water cleanup goals having not been achieved within a 10-year period since the implementation of the LSE remedial action (4 years prior to calcine capping), and concentration trends for some COCs are flat or upwards at some wells, additional assessment of the remedy in meeting the cleanup goals was required by EPA. EPA notified Tronox on April 9, 2008 by transmitting Addendum 1 to the Statement of Work, requiring Tronox to evaluate the likelihood of the remedy achieving cleanup goals within a specifiable timeframe and evaluate the adequacy of the current ground water monitoring network for understanding offsite migration of COC. The monitor well network evaluation report was initially submitted to EPA on August 1, 2008 and is not included in this report.

During 2008 and early 2009, Tronox evaluated the remedial actions performed in 1997 and 2001. Tasks performed as part of this evaluation were detailed in the Addendum I

Work Plan for the Kerr-McGee Chemical Superfund Site, dated January 14, 2009, amended February 4, 2009. Conclusions drawn from completion of the tasks detailed in the work plan are presented below.

6.1 S-X Pond

The S-X pond basin was drained, had sediments removed, and was covered with native soil as part of the original remedy in 1997. The remedy did not require removal of the underlying soils. The inspection conducted as part of this work in 2008 revealed that there are areas within the boundaries of the former pond that contain water after snowmelt. This water could infiltrate through the vadose zone into the ground water beneath the S-X pond. One sink hole was observed during the inspection. This sink hole could be another location where storm water could infiltrate through the vadose zone. Results of the review of the ground water model performed for the RI/FS suggest that the S-X pond had infiltration turned off (no infiltration) following completion of the remedy in forward model runs.

The S-X pond contributed significant mass of COC during plant operations based on RI data. The vadose zone beneath the former S-X pond was not investigated as part of the original remedial investigation (RI). The magnitude of any impacts resulting from storm water infiltrating through the vadose zone cannot be quantified because there are no supporting data from the vadose zone in the S-X basin. Well KM-8 ground water concentration trend results indicate arsenic, manganese, molybdenum, vanadium, TBP, and TPH, all found in the former S-X pond, are present in KM-8 ground water at levels well above the RBC. Trend analysis indicates that the ground water clean up cannot be predicted based on current trends. Sampling of well KM-8 near the former S-X pond indicates that the ground water continues to have an odor comparable with the former S-X pond, suggesting that the basin continues to generate leachate. Surface water infiltration through this pond basin has a potential to generate leachate within the vadose zone and to contribute to ground water COC concentrations, based on observation, inspection and data analysis.

6.2 Scrubber Pond

The 1997 remedy of the former scrubber pond basin required removal of the liquids and sediments and covering the scrubber pond basin with native soil. The inspection conducted as part of this investigation in 2008 indicated areas on the cover that pond storm water and snow melt runoff from the cap. Runoff ponding on the scrubber pond cover that does not reach the infiltration basin, r seeps through the vadose zone into the ground water beneath the scrubber pond or is lost to evapotranspiration where vegetation is present. Results of the review of the ground water model suggest that the scrubber pond had infiltration from the former source turned off following completion of the remedy in forward transport model runs.

As with the S-X pond, the vadose zone beneath the scrubber pond was not investigated as part of the original RI and the remedy did not require removal of the underlying soils. The magnitude of any impacts resulting of any storm water infiltrating through the vadose zone cannot be quantified because there is no data from the vadose zone in this area. Results of HELP modeling from the CAP design document indicate that the cap could shed about 100,000 cubic feet of water onto this cover.

Wells KM-2 and KM-3 ground water concentration results indicate, molybdenum, and vanadium found in the former S-X circuit when this was diverted to the scrubber pond, are present in ground water at levels well above the RBC. Arsenic is near the MCL. Manganese is above the RBC and continues to slowly increase in concentration in well KM-3 ground water. Trend analysis indicates that the ground water clean up to below the RBC cannot be predicted based on current trends in these wells. Sampling of well KM-3 near the former scrubber pond indicates that the ground water samples continue to have an odor comparable with the former scrubber pond. Surface water infiltration through the scrubber pond basin has a probability to generate leachate within the vadose zone and to contribute to ground water COC concentrations, based on 2008 inspection and data analysis presented in Chapter 5 and in Appendix B. Additionally, results from the lysimeters at the historic scrubber/boiler blowdown pond showed in the RI that soils below the scrubber solids have smaller adsorption capacity relative to soils beneath calcine.

6.3 Limestone Settling Pond Area

The unlined limestone settling ponds were covered with native soil when they were replaced with the lined ponds in 1988. The remedy did not require the treatment or closure of these ponds. The lined ponds were removed in 2003 after the vanadium plant ceased operation. The 2008 inspection of the area discovered is the presence of intermittent water running onto the area from an unknown source. This water creates a small pond and contains wetland vegetation above the west calcine and the old unlined settling ponds. A drainage ditch has been excavated from ponded water in this area to the northwest and discharges directly onto the west calcine impoundment area.

During the RI, the vadose zone in the limestone settling ponds area was investigated with lysimeter completions and sampling of soil pore water in the calcine and underlying soils. Soils adsorb metals generated in the vadose zone within the calcine, but none of the covered settling pond solids have been defined in terms of areal extent or depth, nor have these sources been sampled. Therefore, the level of potential impacts resulting from an on-going source of surface water infiltrating through the vadose zone in the settling pond area cannot be quantified because there are no current monitoring data from the vadose zone in this area. The closest well (KM-6) indicates concentrations of molybdenum and vanadium exceeding the RBC, seasonal fluctuations in the COC, with longer term increasing trends correlating with increased annular moisture.

6.4 On-Site Landfill

The inspection of the on-site landfill and review of the construction records indicate that the landfill was constructed as designed. There are no data gaps associated with the construction and operation of the on-site landfill. The landfill will require weed control to ensure that the tap rooted plants do not encroach on the cover.

6.5 Calcine Cap

Limited ground water data are available immediately downgradient of the calcine cap. Well KM-4 indicates a significant mass of COC are contained in the ground near the southwest corner of the cap facility. Some of this elevated COC in well KM-4 may result from the former scrubber pond influence, although the calcine also contained a couple of ponds that were nearly full in 1998. The calcine was not covered until late 2002, therefore it is assumed that mass loading from the calcine to ground water continued through 2002.

The inspection of the calcine cap and review of the construction records indicate that the calcine cap was constructed as designed. Based on this review, no data gaps were identified with the construction and operation of the calcine cap. The cap will require weed control to ensure that the tap rooted plants do not encroach on the cover.

6.6 MAP Ponds

The former MAP ponds were filled and covered with native soil after the MAP was excavated. The vanadium production and MAP process was changed to make these ponds obsolete. These ponds were removed from service in 1993. The affects of removing the MAP ponds was noted in the water quality in well KM-5. The inspection of the former MAP ponds showed that there is a low lying area within the former pond boundaries and evidence of storm water run-on along the north and south sides of the former pond from the current process areas. Ponded storm water potentially infiltrates the vadose zone into the ground water beneath the former pond.

As with the S-X and scrubber pond areas, the vadose zone in the MAP area was not investigated during the RI. The magnitude of impacts resulting of any storm water infiltrating through the vadose zone cannot be quantified because there are no data from the vadose zone in this area. The MAP product was sold for fertilizer application, therefore, it is possible that very little to no MAP product remains beneath the soil cover. However, well KM-5 monitors ground water affected by this pond area, as shown during the RI. Vanadium ground water concentrations in well KM-5 are seasonal, relatively flat, whereas molybdenum is at or below the RBC.

6.7 Former Vanadium Plant

The vanadium plant ceased operation in 2000 and was demolished in 2002. Following demolition of the plant, the footprint was covered with limestone fines. The inspection of this area showed that there are foundations from the former plant that are not covered and there are low lying areas that accumulate storm water. Storm water and snowmelt could infiltrate through the vadose zone beneath the former plant from these low lying areas or along the soil concrete contact where the foundations are exposed.

The current cover permeability is unknown. The limestone cover for the most part provides positive drainage, although it is likely that infiltration is occurring through the cover, particularly where coarser rock cover exists. The vadose zone beneath the plant area was not investigated during the original RI. The magnitude of impacts resulting from rainfall or snowmelt infiltration through the vadose zone or the plant foundation cannot be quantified because there are no data from the vadose zone in this area. It appears that little soil exists in the vicinity of the former plant and that the foundation of the former plant is near the bedrock elevation. Ground water in the vicinity of the plant is not monitored, so the impact, if any from the former plant to ground water is not known. If an impact from the former plant site to ground water is occurring, the impact potential from the calcine impoundment located immediately upgradient of the plant could potentially mask this contribution.

6.8 West Calcine

Calcine from the early operation of the facility (1963 through 1972) was impounded on the west side of the facility and covered with native soil ranging in thickness from about 6 inches to 5 feet. Lysimeter results indicate that the calcine generates vanadium that is adsorbed by soils below the calcine where these soils exist. During 2008 inspection of the west calcine, a source of surface water was discovered that saturates a portion of this calcine. The cover of the west calcine is thin. Calcine is exposed in a few locations between the settling ponds and the S-X pond cover. Most of the cover is vegetated and there is evidence of animal burrowing in a number of areas. The calcine is monitored by shallow wells KM-6, KM-7, KM-8, KM-9, KM-12 and KM-13. Infiltration through the west calcine potentially results in some impacts to ground water. However, these effects may be masked by the presence of impacted soils in the vadose zone beneath the former S-X pond that overlies the calcine.

6.9 Former Scrubber/Boiler Blowdown Pond

Lysimeter data obtained during the RI indicated that the leachate through the former scrubber/boiler blowdown pond potentially impacts ground water. Well KM-5 is downgradient of this former scrubber/boiler blowdown pond area, based on site gradient contours. Vanadium ground water concentration trend in well KM-5 is relatively flat after 2004, whereas molybdenum is at or below the RBC in this well. Vanadium concentrations are seasonal in this well with the larger concentrations occurring in the spring. Based on the results of well KM-5, this former pond source cannot be ruled out as a contributor to ground water impact.

6.10 Ground Water Quality Trends

Based on a review of water quality trends with water levels, the MAROS analysis presented in Appendix B, regression analysis of ground and surface water quality data from 1997 through May 2008, recent water quality trends between 2004 and 2008 and predictions of future concentrations, the following conclusions are drawn.

- Vanadium and molybdenum continue to exceed the RBC at most of the on-site wells. The largest continued impacts to ground water noted on the site occur immediately downgradient of the former scrubber and S-X pond basins.

- Results from the plume analysis and spatial moment analysis using the MAROS program indicate that both molybdenum and vanadium plumes have decreased since LSE was performed in 1997. Concentrations in most wells show a decreasing trend with few exceptions. Recent data, (data evaluated since 2004) reflect a slower rate of change, with some wells reaching a flat slope showing no trend or even a slightly increasing trend. Both the plume and spatial moment analysis illustrate that molybdenum and vanadium have different reactions and migration patterns in the subsurface.

- Predicted ground water concentrations for molybdenum and vanadium in the wells monitoring the former S-X (well KM-8) and scrubber ponds (wells KM-2, KM-3 and KM-4) indicate these COC could exceed the vanadium RBC for sixty or more years following LSE. Well KM-8 has no predictable trend. Ground water data obtained from 2004 to 2008 indicate increasing trends for these wells. This period of time is longer than RI/FS modeling estimates for LSE. Ground water results since 2004 suggest that the soils beneath these pond basins are leaching COC to ground water, or that the natural attenuating properties of ground water system can no longer reduce the level of COC in ground water beneath these pond basins.

- In most cases, predicted clean up times are longer for vanadium based on data obtained from 2004 to 2008 when compared with estimated clean up times using the full data set since LSE (1997).

- Increasing COC concentrations since 2004 are noted in wells KM-6 and KM-16 that coincide with rising water levels and increased annular moisture in the aquifer following years of drought.

- Seasonal concentration trends are noted at a large percentage of well locations. These seasonal effects are less discernable for vanadium in a number of wells between October 2001 and in October 2008. Vanadium does not appear seasonal in wells KM-3, KM-4 and KM-8 based on the Kendall seasonal tests.

- A decreased pH in the ground water between 1999 and 2001 may have caused increased metals concentrations in some POC wells during that period. The pH is now near-neutral across the site and at off-site locations, with the exception of the area around the former S-X pond.

- Finch and Big Spring exceed the RBC for molybdenum only. Both locations continue to indicate decreasing trends that are now close to the RBC. Trend analysis suggest that Finch Spring may fall below the RBC in 2009

- Vanadium concentrations in Finch Spring remain elevated but are less than the RBC, and vanadium is less than the reporting limit in Big Spring.

6.11 Institutional Controls

The Consent Decree required that institutional controls be placed on the industrial site and the private property to the south of the site. The Consent Decree required that these institutional controls must be protective of human health and the environment. The Consent Decree required controls that will not allow the consumption of ground water except for the treating and monitoring of ground water contamination and no use or activity will disturb any remedial actions that have been taken. In 1996 Tronox (Kerr-McGee Chemical at the time) negotiated an easement with land owner. This easement was attached to the chain of title by recording it with the Caribou County Clerk. This easement is considered a Proprietary Control by the guidance document. This control appears to be adequate.

The site has remained an industrial site the entire time since the Consent Decree was signed. The facility is connected to the City of Soda Springs public water supply and uses this water or bottled water for all domestic purposes. The facility has not prepared a document that details the water use requirements or established any easements or other Proprietary Controls that are attached to the chain of title to restrict land use in the future. This has not been completed because it was not anticipated that the property would be out of the control of Kerr-McGee or its successors and the property would remain an industrial facility for the foreseeable future. These controls have been effective in the past, but establishing documented Proprietary Controls within the chain of title may be required in the future.

Institutional controls for ground water consumption beyond property controlled by Tronox or the City of Soda Springs has not been considered since this ground water is not consumed. The City of Soda Springs requires building permits and hooking up to the city water supply if any development were to occur. This control meets the Governmental Controls requirements. This control does not appear to be adequate because Tronox has recently learned that anybody could obtain a drilling permit for a domestic well from the Idaho Department of Water Resources. However, this risk does not appear to be a large since there has been no development in the last 10 years and any future development is unlikely.

The vanadium concentration Finch Spring and Big Spring is smaller than the risk-based concentration and the molybdenum concentration at these springs is falling to near the risk-based concentration. Analysis presented in this document suggests that molybdenum may be below the RBC at Finch Spring in 2009. Institutional controls in this area (to the south of the site on uncontrolled property) should not be a concern once the concentration of COC in these springs falls below the risk-based levels.

7.0 RECOMMENDATIONS

The findings and conclusions of the remedy evaluation support the following recommendations:

Covered S-X Pond – Potential impacts from the vadose zone to the ground water require assessment in this former pond basin because this basin was not investigated during the RI. The former pond is adequately monitored by ground water wells. Therefore, the types of studies required to investigate the covered S-X pond site would include soil borings and geologic logging to characterize subsurface conditions, analyses of the selected samples retrieved from these borings, installation of lysimeters and collection of soil pore water that would be representative of potential leachate for analysis. Limits of the S-X pond investigation area would be within the previously identified basin and below high water boundaries of the former pond to bedrock. Some of this investigated area will overprint on the west calcine limits beneath this former pond area. Results of the investigation would be interpreted and assessed for potential for contribution to ground water, and assessed for the identification of remedial technologies to address the soils in the former pond based on the findings.

Covered Scrubber Pond – Potential impacts from the vadose zone to the ground water require assessment in this former pond basin that was not investigated during the RI. The site is adequately monitored by ground water wells to the west. However, based on gradient analysis between wells KM-2 and KM-3, a southerly flow component cannot be ruled out entirely.

The types of studies required to investigate the covered scrubber pond would include soil borings and geologic logging to characterize subsurface conditions to bedrock, analyses of the selected samples retrieved from these borings and in-situ testing, such as the installation of lysimeters and collection of soil pore water that would be representative of potential leachate from soils impacted by scrubber pond waters. If soil borings intercept the shallow aquifer in this area, water quality can be assessed in the alluvial aquifer, if present. Limits of the investigation of the former scrubber pond would be south of the calcine cap fence within the previously identified high water boundaries to bedrock. Results of the investigation in the scrubber pond basin area would be interpreted and assessed for potential contribution to ground water, and assessed for the identification of remedial technologies.

Vanadium Plant – The vanadium plant is a potential source of COC to ground water based on field inspection. However, this impact cannot be assessed because there are no historic ground water data to show an impact to ground water exists, or to demonstrate that no impact exists. An evaluation of the vadose zone is not practical because the plant rests predominantly on bedrock. Therefore, a monitor well immediately west of the S-X processing part of the former plant appears to be the single alternative to addressing possible impacts from the former facility.

Former Limestone Settling Ponds – The source of surface water that is currently infiltrating the limestone settling pond area should be identified, characterized and terminated. This will require locating underground infrastructure or piping to permanently abandon the source of constant surface water overlying potentially uncontained sources. Potential impacts from the vadose zone to the ground water require assessment in this area because sediments from the covered ponds were not located in the field, characterized, or otherwise investigated during the RI. The site does not appear to have been included in RI/FS forward modeling since no characterization of the site was completed.

The site is adequately monitored by ground water wells KM-6 and KM-7. Therefore, the types of studies required to investigate this site would include soil borings and geologic logging to characterize subsurface conditions, analyses of the selected samples retrieved from these borings and the installation of lysimeters and collection of soil pore water that would be representative of potential leachate from one or more locations within and below source material. Limits of the investigation would be within the fenced area currently surrounding the covered ponds to the bedrock surface. Results should be interpreted and assessed for potential contribution to ground water, and assessed for the identification of remedial technologies, should significant contributions to ground water be implicated from the investigations.

MAP Ponds – The MAP product was reported in the RI to have been removed from these ponds prior to closure. Several soil borings should be placed in this area to characterize subsurface conditions and to confirm that MAP product is not remaining or that other process material does not exist in the vadose zone. Well KM-5 was affected by the MAP ponds as shown in the RI, but the recent flattening vanadium concentrations and seasonal changes in well KM-5 may result from on-going affects from the boiler blowdown/scrubber pond source, or another source to the east of well KM-5, including the former vanadium plant facility and calcine.

Boiler Blowdown Scrubber Pond - Data from lysimeters L-4 and L-5 were input into the ground water model that was completed for the RI/FS. Well KM-5 is downgradient/lateral gradient from the boiler blowdown/scrubber pond. The recent flattening of the vanadium concentration and seasonal changes in well KM-5 may result from on-going affects from the boiler blowdown/scrubber pond infiltration, or from another source to the east of well KM-5, including the former vanadium plant facility and the calcine. The types of studies required to investigate the boiler blowdown/scrubber pond includes drilling a number soil borings within the pond basin area defined by the immediate surrounding plant roads and in areas to the west and south of the covered pond to characterize subsurface conditions. Activities include geologic logging, analyses of selected samples retrieved from these borings and installation of lysimeters and collection of soil pore water that would be representative of leachate potential. Results would be interpreted and assessed for potential contributions to COC in ground water, and assessed for potential remedial technologies, if required.

West Calcine - Soil pore-water data obtained from lysimeters L-1 and L-2 were input into the ground water model that was completed for the RI/FS to represent COC concentrations available from this solid source. The site is adequately monitored by ground water wells downgradient to the west and south of this source. Well KM-7 is completed in bedrock directly beneath this site. Seasonal vanadium concentration changes in well KM-7 may result from infiltration through the west calcine in the spring, leaching from the on-going surface water source on the limestone settling ponds, or result from another contributing source to the east of well KM-7, including the former vanadium plant facility, calcine or the scrubber pond. Potential impacts from the S-X pond basin and limestone settling ponds occur within the west calcine limits. Therefore, the patterns of COC noted in the ground water in wells KM-6, KM-7, KM-8, KM-9, KM-12 and KM-13 result from the combined effects of these sources.

Consequently, to supplement the vadose investigations of the limestone settling ponds and the S-X pond basin, a number soil borings should be drilled in areas of the west calcine to characterize subsurface conditions and to confirm the assumptions of "calcine resting on soil" to support RI conclusions. In particular, areas where calcine rests directly on or near bedrock should be identified. A lysimeter should be installed at the bedrock interface where this condition occurs. Collection of soil pore water within the calcine would allow for assessment that would be representative of leachate characteristics. Results would be interpreted and assessed for potential contribution to ground water, and assessed for the identification of potential remedial actions.

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TABLE 1-1
CHRONOLOGY OF PROCESS CHANGES

Event	Date(s)	Comments
S-X stream diverted from the S-X pond to the scrubber pond	1992 through 1993	Flow may have been diverted between ponds during this time period.
MAP ponds taken out of service; third roaster taken off-line in April	1993	Ponds reclaimed. Effects of remediation apparent in well KM-5.
S-X pond receiving discharge from S-X circuit	1994	S-X circuit discharge diverted to S-X pond for last time.
S-X stream diverted from the S-X pond to the scrubber pond	Late 1994 to mid 1995	S-X pond contained residual process water during 1995
S-X stream diverted to newly-constructed lined ponds	Mid 1995	Precipitation continued to fill the S-X pond basin and infiltrate. Pond contained significant volume of precipitation during 1996-1997 winter.
Scrubber pond taken out of service	April 1997	Scrubber pond pumped to the calcine pond. Some scrubber stream sent to calcine ponds. Residual liquid in pond and meteoric water drained out during stabilization of the pond sediments. All baghouses on-line in October.
Discontinue sluicing calcine	April – October 1997	Calcine dewatered, and residual water recycled in process. Dewatered calcine stockpiled north of the calcine impoundment.
Fertilizer Plant Operational	July 1998 to May 2000	Calcine removed from active calcine Impoundment, processed to fertilizer. Reject fertilizer placed in calcine impoundment.
Discontinue Vanadium Processing – Vanadium Plant Idle	January 1999 to present	Discontinue stockpiling of calcine, discontinue all vanadium process streams to lined ponds, discontinue the recycle of roaster reject.
Cap Active Calcine Impoundment	May 2001 through August 2001	Calcine was capped using multi-component cover to eliminate meteoric infiltration through calcine tailing. Substantial amount of dust control/construction water used.
Dismantle Vanadium Plant	November 2001 through May 2002	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade. Footprint regraded with limestone fines in April/May 2003
Dismantle Fertilizer Plant	November 2002 through June 2003	Materials removed to approved facility, surface footprint cleaned in preparation for surface regrade.
Reclaim Stormwater Runoff Ponds	September through October 2003	Solids and liquids removed to 10-acre pond, site regraded and reclaimed.
Reclaim 5-Acre Ponds	September through October 2004	Solids and liquids removed to 10-acre pond, east pond site regraded and reclaimed.
Regrade Scrubber Pond Cover	November 2005	Fill and regrade south of calcine cap

Note: Changes in the discharge locations of both the S-X and scrubber streams affected concentrations in both on-site and off-site wells and Finch Spring during operation.

TABLE -2-1
MONITOR WELL CONSTRUCTION AND WELL TESTING RESULTS

Well Designation	Completed Date	Northing	Easting	Elevation Top of PVC Feet msl	Elevation Concrete Pad Feet)	Top of Screen	Bottom of Screen	Hydraulic Conductivity (ft/day)	Unit Monitored	Lithology Screened Interval
KM-7	09/26/91	372113.189	658578.407	6001.63	5999.90	46.2	56.2	na	Qb5/I4	vesicular basalt and cinders
KM-10	10/12/91	373073.856	659761.715	6029.43	6027.90	100	120	na	Qb3	basalt
KM-6	09/24/91	371736.929	658601.626	5988.13	5986.00	34.7	44.7	340	Qb5	vesicular basalt
KM-2	09/21/91	371777.028	660379.196	6025.11	6023.00	47.2	57.2	266	Qb5	basalt, clay
KM-1	10/07/91	373073.394	659740.078	6029.72	6027.50	45.9	55.9	204	I4	clay, tuff
KM-4	10/02/91	372033.826	659695.190	6023.44	6021.90	43.7	53.7	153	I4	cinders, tuff
KM-15	09/24/92	370332.04	657491.89	5958.10	5956.20	45.2	55.2	105	Qb5a/I5	cinders, basalt
KM-16	09/18/92	371058.74	658151.12	5998.97	5997.20	63.3	73.3	97	Qb5	basalt
KM-11	10/29/91	371745.582	659847.119	6013.63	6012.10	80	100	96	Qb3	basalt
KM-3	10/11/91	371745.657	659825.555	6014.28	6012.20	39.1	49.1	91	I4	clay, tuff
KM-9	09/29/91	371770.477	657836.280	5973.56	5971.50	47.5	57.5	48	Qb5	vesicular basalt
KM-5	10/01/91	372710.706	658856.602	6002.72	6001.50	38	48	37	Qb5	vesicular basalt
KM-12	10/29/91	371778.391	658119.553	5976.07	5973.90	134.1	154.1	34	Qb3	basalt
KM-13	10/07/91	372185.749	658042.505	5977.65	5975.60	46.4	56.4	17	Qb5	basalt
KM-19	10/15/92	371788.11	658085.74	5975.17	5973.80	193.6	213.6	15	Qb2/I1	fractured basalt, clay
KM-8	10/21/91	371771.964	658144.161	5976.75	5974.40	34.6	44.6	9.4	Qb5	basalt, clay
KM-18	10/03/92	370336.14	657468.67	5958.25	5956.80	152.6	172.6	8.2	Qb3	basalt
KM-17	09/25/92	371100.35	659365.30	6001.11	5999.60	38.2	48.2	2.3	Qb4/I3	basalt, silt

TABLE 2-2
MAXIMUM CONCENTRATIONS OF COC AND MOST CURRENT CONCENTRATIONS IN TRONOX WELLS AND OFF-SITE SPRINGS

Well Designation	Arsenic Concentrations		Manganese Concentrations		Molybdenum Concentrations		Total Petroleum Hydrocarbons Concentrations		Tributyl Phosphate Concentrations		Vanadium Concentrations	
	PROPOSED RBC = 10 ug/l		RBC = 180 ug/l		RBC = 180 ug/l		RBC = 0.73 mg/l		RBC = 180 ug/l		RBC = 260 ug/l	
	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)	Largest (mg/l)	Most Current (mg/l)	Largest (ug/l)	Most Current (ug/l)	Largest (ug/l)	Most Current (ug/l)
KM-2*	53	13	444	31	11800	1000	2.0	NA	7	NA	15500	4700
KM-3*	27	12	1680	570	44900	6500	1.8	NA	1400	NA	13200	3300
KM-4	63	11	1160	100	15300	2200	NA	NA	NA	NA	23300	6900
KM-5*	12.2	2.6	399	7.2	1460	160	NA	NA	3	NA	15800	1100
KM-6	6.5	5.3	291	180	2140	1200	2.0	NA	110	NA	6630	3900
KM-7	6.9	4.2	197	79	593	390	2.0	NA	NA	NA	3410	2100
KM-8*	170	97	8770	4900	165000	47000	9.5	2.2	4442	830	29000	16000
KM-9*	5	2.1	113	6.7	1740	150	NA	NA	ND	NA	3590	430
KM-11*	2	0.35	157	17	5600	290	0.42	NA	112	NA	492	11
KM-12*	23	1.5	177	26	9290	430	0.39	NA	13	NA	5580	600
KM-13*	4	1.5	131	8.6	6790	230	0.18	NA	12	NA	6420	460
KM-15	5.6	2.0	543	55	6950	380	0.15	NA	484	NA	3840	860
KM-16	7.3	3.5	364	99	2300	700	1.9	NA	180	NA	4250	2100
KM-17	1.5	ND	84	2.1	987	380	1.2	NA	170	NA	493	15
KM-18	3.7	1.6	332	42	6340	360	1.3	NA	410	NA	2990	650
KM-19*	2	0.76	32.3	2.5	258	20	1.1	NA	4	NA	558	120
Big Spring	1.1	0.77	1.8	ND	508	200	NA	NA	NA	NA	13.6	3.7
Finch Spring	2	0.7	4.4	ND	663	190	0.22	NA	ND	NA	91.7	64
Upper Ledger	3.7	0.29	2.6	ND	22.4	ND	NA	NA	NA	NA	5.1	ND
Lower Ledger	4.2	0.32	1.5	ND	54.1	ND	NA	NA	NA	NA	14.9	ND

Footnotes:
* = Point of Compliance Well
NA = Not Available – not sampled during May 2007
ND = Not Detected (less than IDL)
Shaded cells indicate exceedence of RBC

TABLE 5-1
PROJECTED COC TRENDS
BASED ON NOVEMBER 1997 THROUGH MAY 2008 DATA

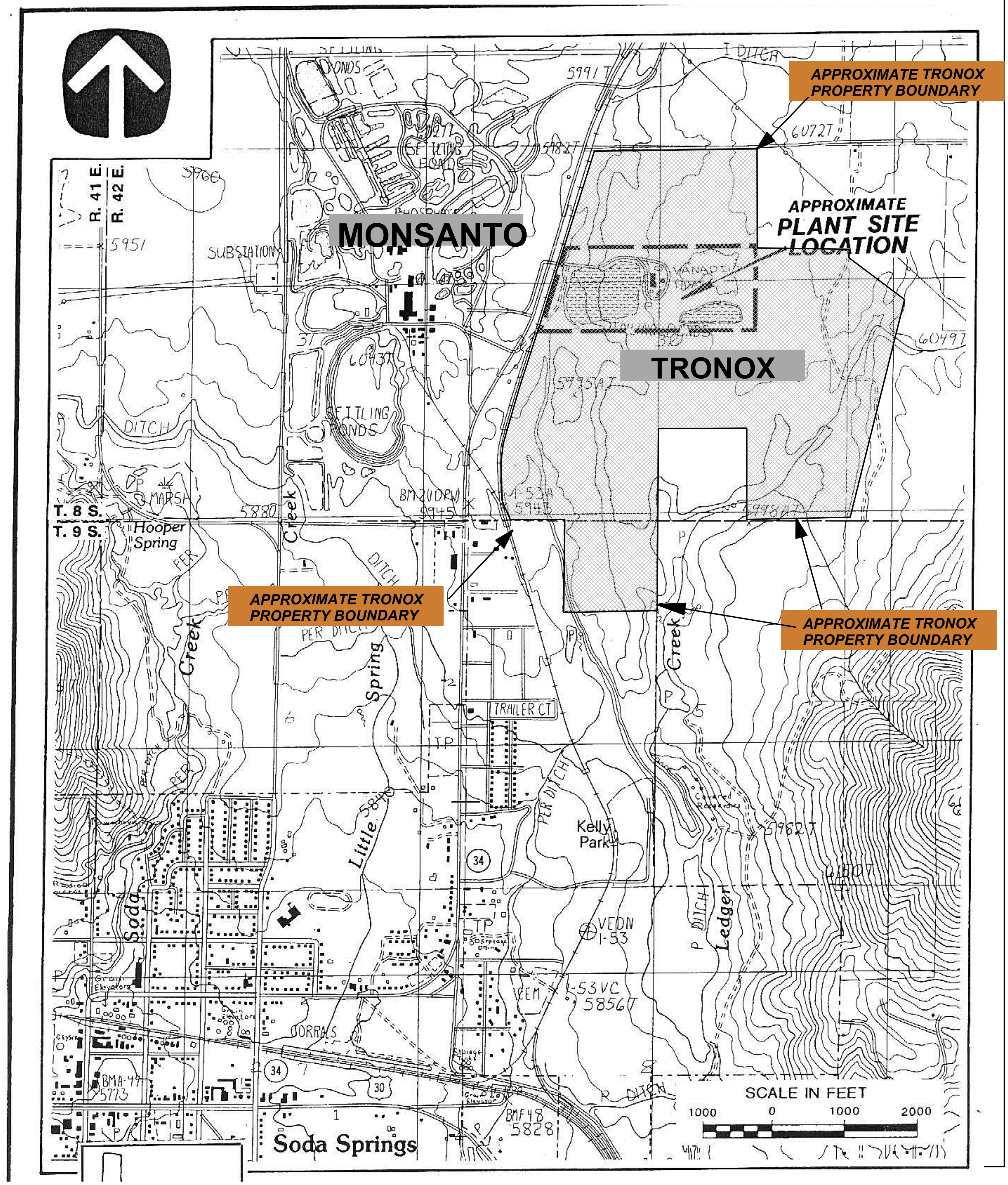
	MANGANESE				MOLYBDENUM				VANADIUM			
Monitor Well	**May 2008 Conc. (ug/l)**	**Projected Year Below RBC**	**Regression Equation**	**Regression Coefficient**	**May 2008 Conc. (ug/l)**	**Projected Year Below RBC**	**Regression Equation**	**Regression Coefficient**	**May 2008 Conc. (ug/l)**	**Projected Year Below RBC**	**Regression Equation**	**Regression Coefficient**
KM-2	31	Below RBC			1000	2019	y = 2E+09e-$^{0.0111x}$	R2 = 0.6533	4700	2037	y = 5E+07e-0.0072x	R2 = 0.7631
KM-3*	570	Increasing			6500	2030	y = 4E+08e-0.0087x	R2 = 0.4901	3300	2072	y = 90480e-0.0028x	R2 = 0.1199
KM-4	100	Below RBC			2200	NE			6900	NE		
KM-5*	7.2	Below RBC			160	Below RBC			1100	2026	y = 3E+06e-0.0061x	R2 = 0.7269
KM-6	180	At RBC			1200	2034	y = 2E+06e-0.0057x	R2 = 0.4174	3900	2087	y = 142495e-0.0028x	R2 = 0.2847
KM-7	79	Below RBC			390	NE			2100	NE		
KM-8*	4900	2042	y = 4E+06e-0.0057x	R2 = 0.2565	47000	2042	y = 4E+09e-0.0092x	R2 = 0.7271	16000	Increasing	y = 11.643e0.0059x	R2 = 0.2756
KM-9*	6.7	Below RBC			150	Below RBC			430	2012	y = 2E+06e-0.0067x	R2 = 0.9413
KM-11*	17	Below RBC			290	NE			11	Below		
KM-12*	26	Below RBC			430	2017	y = 1E+07e-0.0078x	R2 = 0.9108	600	2022	y = 477960e-0.0002x	R2 = 0.9349
KM-13*	8.6	Below RBC			230	2008	y = 7E+09e-0.0134x	R2 = 0.877	460	2017	y = 272600e-0.0049x	R2 = 0.8757
KM-15	55	Below RBC			380	2014	y = 646759e-0.0053x	R2 = 0.7734	860	2026	y = 551878e-0.0002x	R2 = 0.8659
KM-16	99	Below RBC			700	2022	y = 1E+07e-0.0076x	R2 = 0.6957	2100	2046	y = 743769e-0.0045x	R2 = 0.7361
KM-17	2.1	Below RBC			380	2031	y = 23755e-0.0031x	R2 = 0.2874	15	Below		
KM-18	42	Below RBC			360	2013	y = 4E+07e-0.009x	R2 = 0.8054	650	2022	y = 646759e-0.0053x	R2 = 0.911
KM-19*	2.5	Below RBC			20	Below RBC			120	Below		
Finch		Below RBC			190	2009	y = 2E+07e-0.0089x	R2 = 0.9435	64	Below		
Big Spring		Below RBC			200	2009	y = 555186e-0.0061x	R2 = 0.9251	3.7	Below		

SHADED CELL INDICATES CURRENT EXCEEDENCE OF RBC

TABLE 5-2
PROJECTED COC TRENDS BASED ON MAY 2004 THROUGH MAY 2008 DATA

	MOLYBDENUM				VANADIUM			
Monitor Well	**May 2008 Conc. (ug/l)**	**Projected Year Below RBC**	**Regression Equation**	**Regression Coefficient**	**May 2008 Conc. (ug/l)**	**Projected Year Below RBC**	**Regression Equation**	**Regression Coefficient**
KM-2	1000	2025	y = 3E+07e-0.0078x	R2 = 0.5015	4700	Increasing Trend	y = 1334.6e0.001x	R2 = 0.0239
KM-3*	6500	2075	y = 1E+06e-0.0042x	R2 = 0.6095	3300	2040	y = 3E+06e-0.0054x	R2 = 0.0687
KM-4	2200	NE			6900	NE		
KM-5*	160	Below RBC			1100	2082	y = 10166e-0.0017x	R2 = 0.034
KM-6	1200	Increasing Trend	y = 205.34e0.0015x	R2 = 0.0206	3900	Increasing Trend	y = 23.833e0.004x	R2 = 0.1022
KM-7	390	NE			2100	NE		
KM-8*	47000	Increasing Trend	y = 1151.4e0.0027x	R2 = 0.0311	16000	2042	y = 1E+09e-0.0085x	R2 = 0.3468
KM-9*	150	Below RBC			430	2017	y = 114508e-0.0043x	R2 = 0.5276
KM-11*	290	NE			11	Below RBC		
KM-12*	430	2015	y = 4E+08e-0.0105x	R2 = 0.9602	600	2019	y = 2E+06e-0.0002x	R2 = 0.9796
KM-13*	230	2009	y = 2E+10e-0.014x	R2 = 0.7951	460	2027	y = 16560e-0.0027x	R2 = 0.5342
KM-15	380	2026	y = 60562e-0.0001x	R2 = 0.2171	860	2069	y = 7086.3e-5E-05x	R2 = 0.1543
KM-16	700	2096	y = 4874.5e-0.0014x	R2 = 0.0204	2100	Increasing Trend	y = 2690.9e-9E-05x	R2 = 0.0002
KM-17	380	2014	y = 3E+07e-0.0086x	R2 = 0.7687	15	Below RBC		
KM-18	360	2021	y = 298096e-0.0051x	R2 = 0.328	650	2035	y = 30253e-0.0029x	R2 = 0.5077
KM-19*	20	Below RBC			120	Below RBC		
Finch Spring	190	2009	y = 794176e-0.0064x	R2 = 0.8517	64	Below RBC		
Big Spring	200	2009	y = 1E+06e-0.007x	R2 = 0.8344	3.7	Below RBC		

SHADED CELL INDICATES EXCEEDENCE OF RBC



REFERENCE: U.S.G.S. QUADRANGLE SODA SPRINGS, IDAHO PROVISIONAL EDITION 1982.

APPROXIMATE TRONOX PROPERTY BOUNDARY LOCATION MAP

FIGURE 1-1

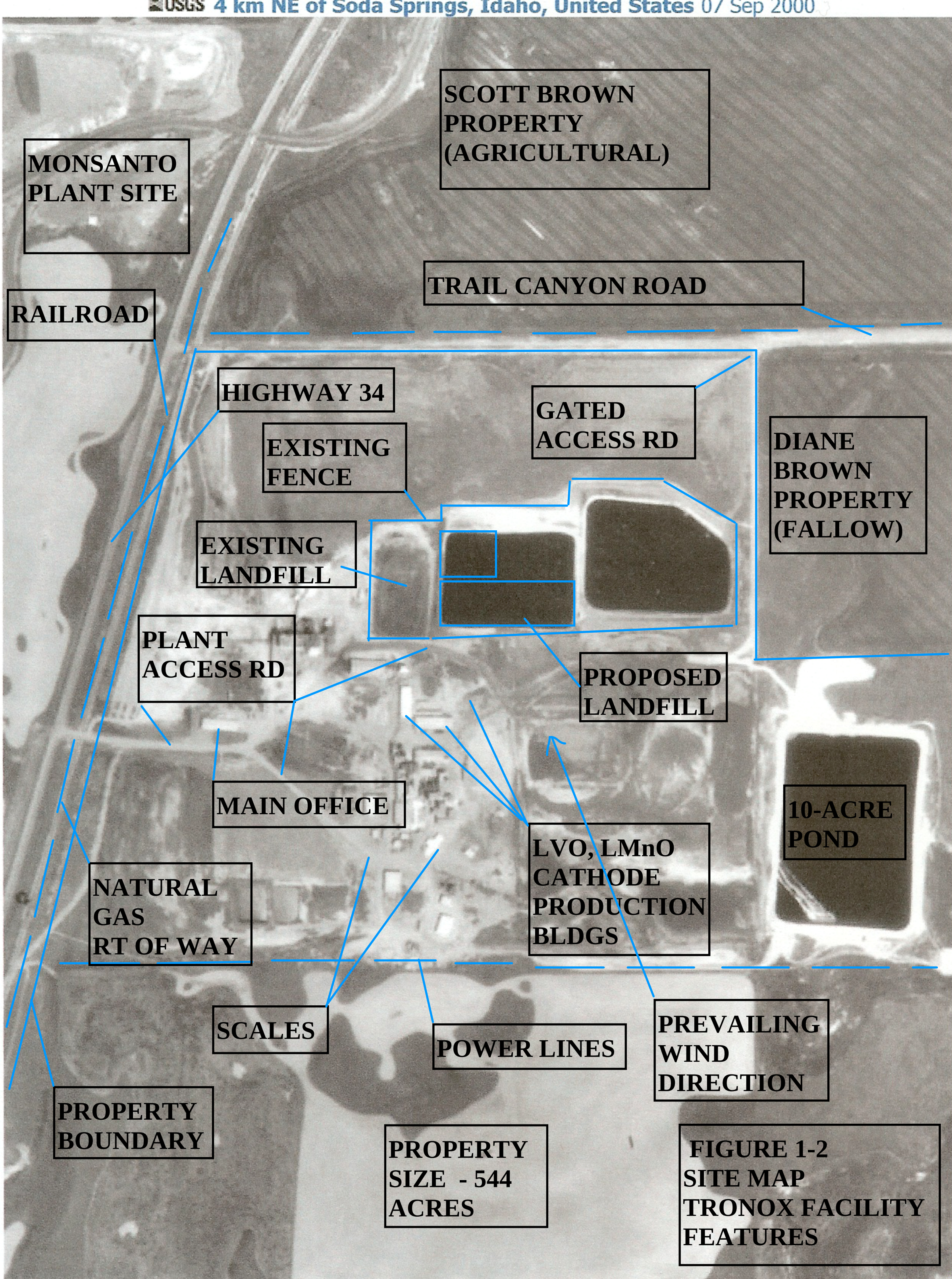
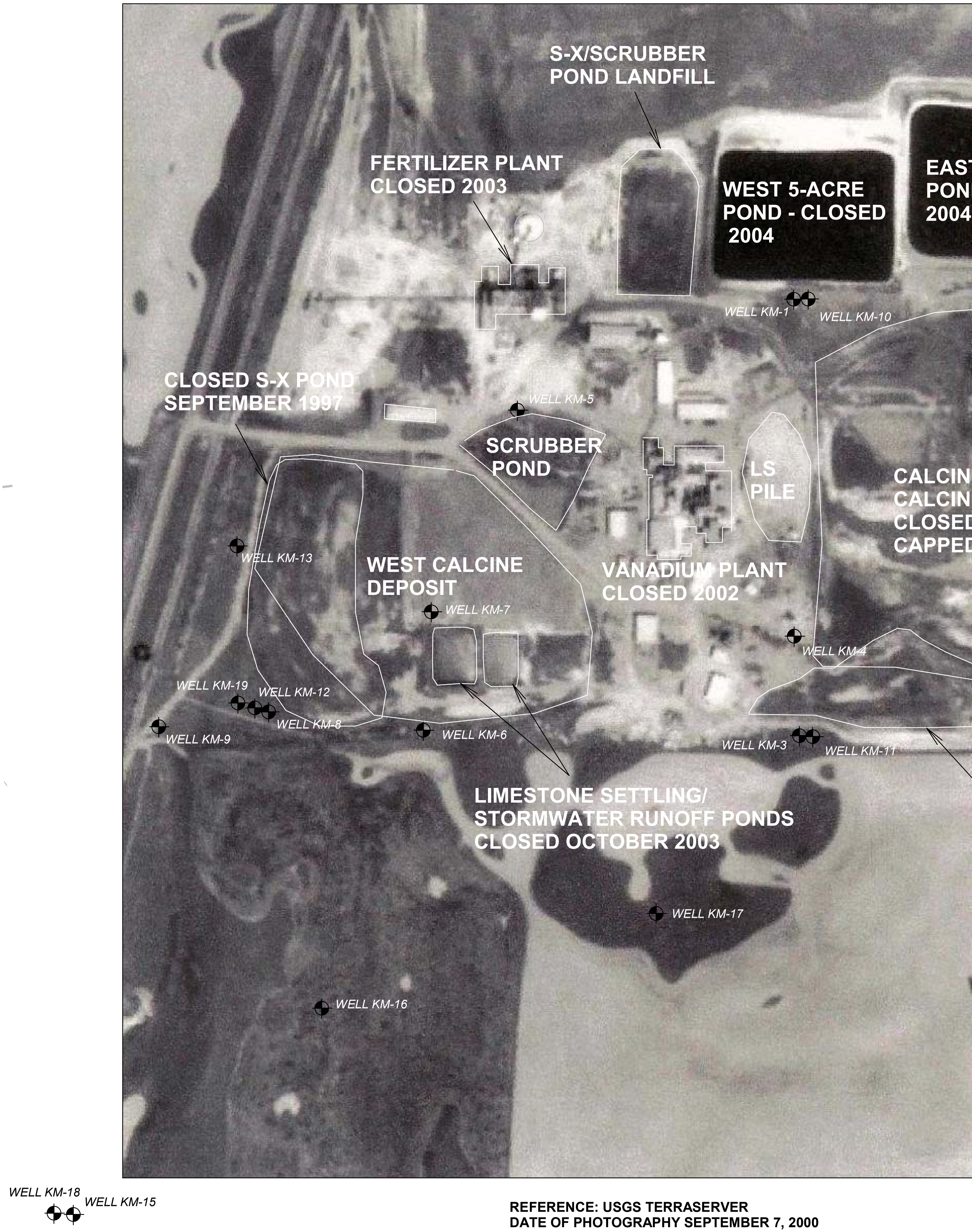


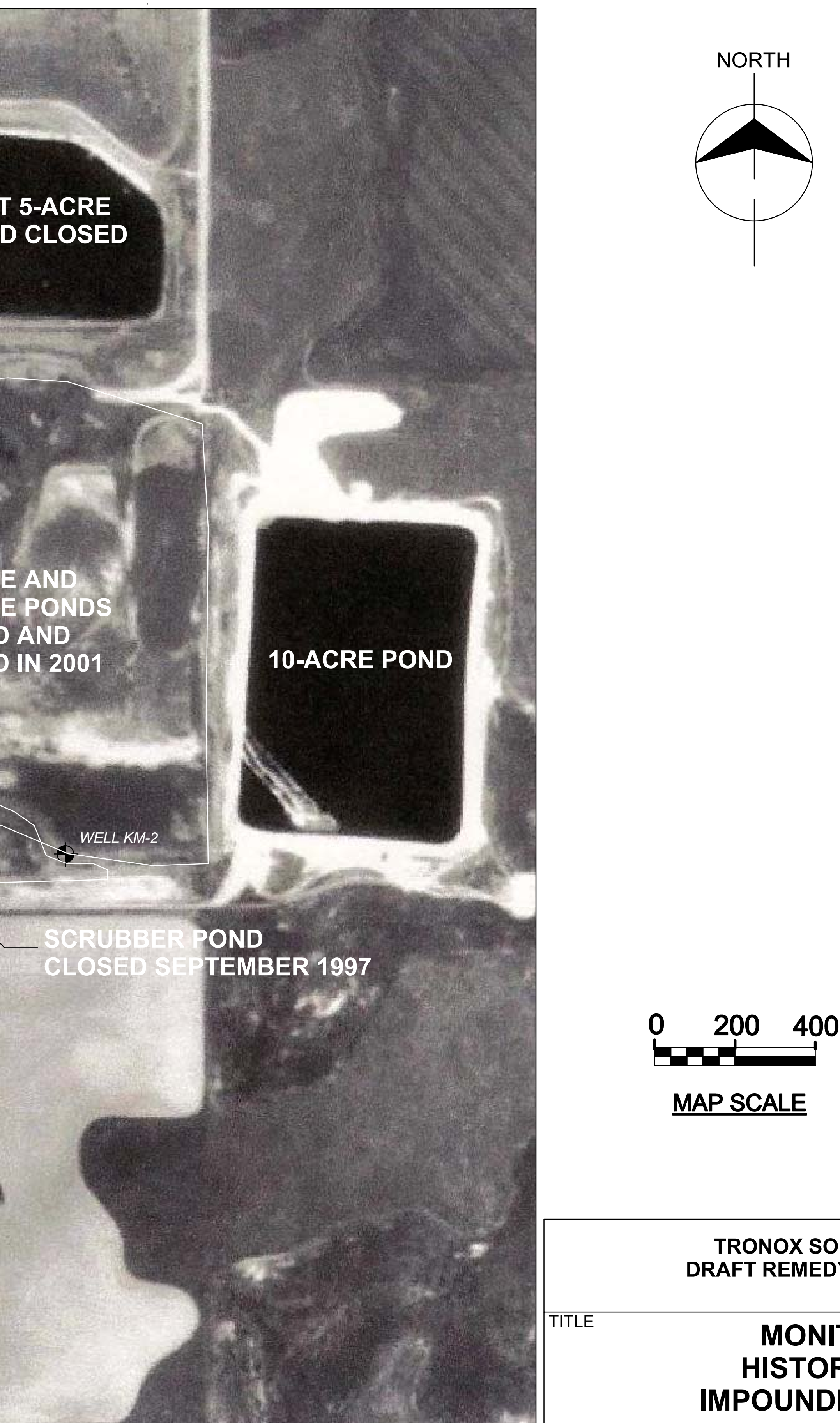
FIGURE 1-2
SITE MAP
TRONOX FACILITY
FEATURES

4 3



REFERENCE: USGS TERRASERVER
DATE OF PHOTOGRAPHY SEPTEMBER 7, 2000

4 3

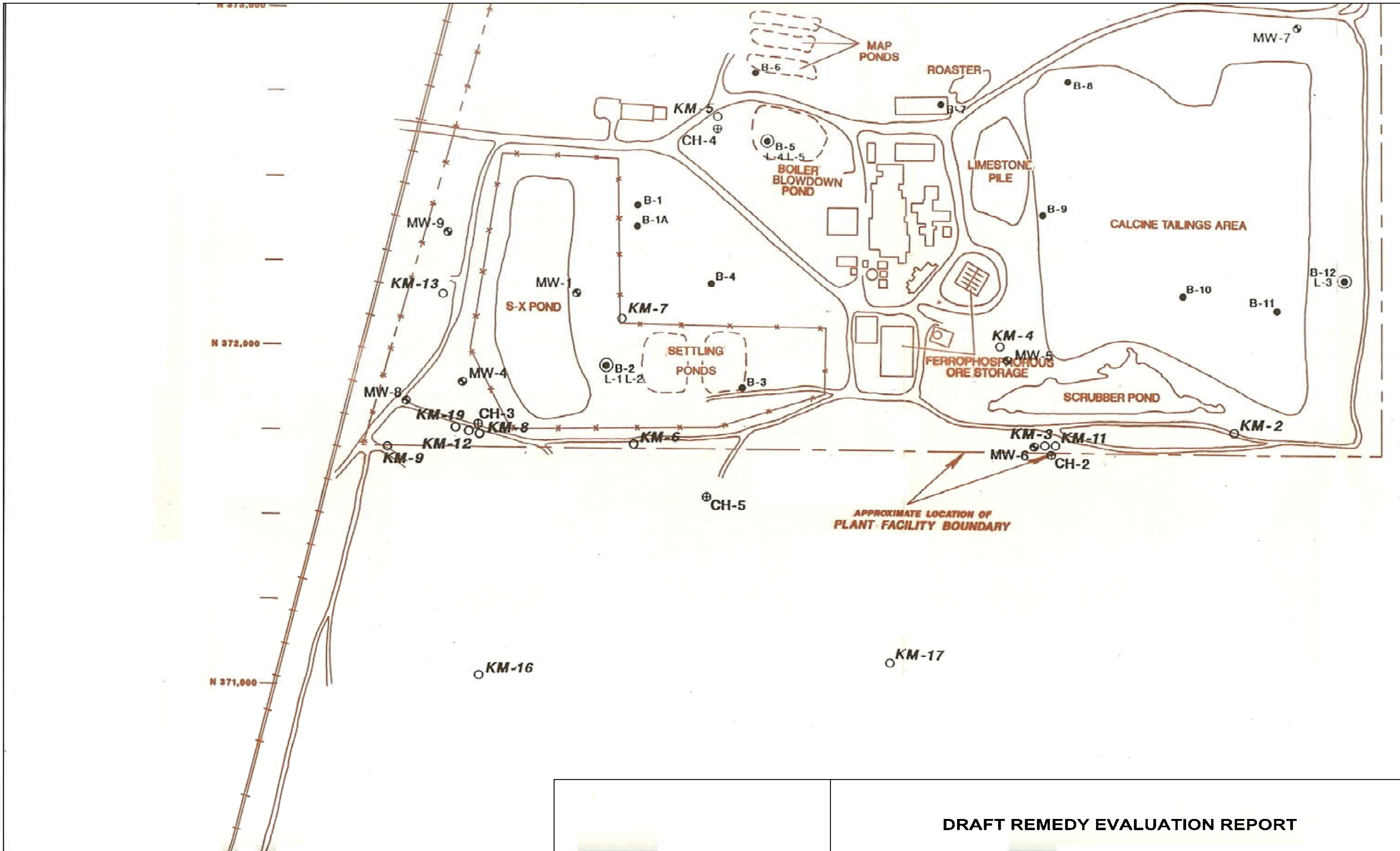


TRONOX SODA SPRINGS, IDAHO
DRAFT REMEDY EVALUATION REPORT

TITLE	MONITOR WELLS, HISTORIC POND AND IMPOUNDMENT FEATURES		
SIZE B	CAGE CODE	DWG NO	REV
SCALE		SHEET FIGURE 1-3	

4/15/08

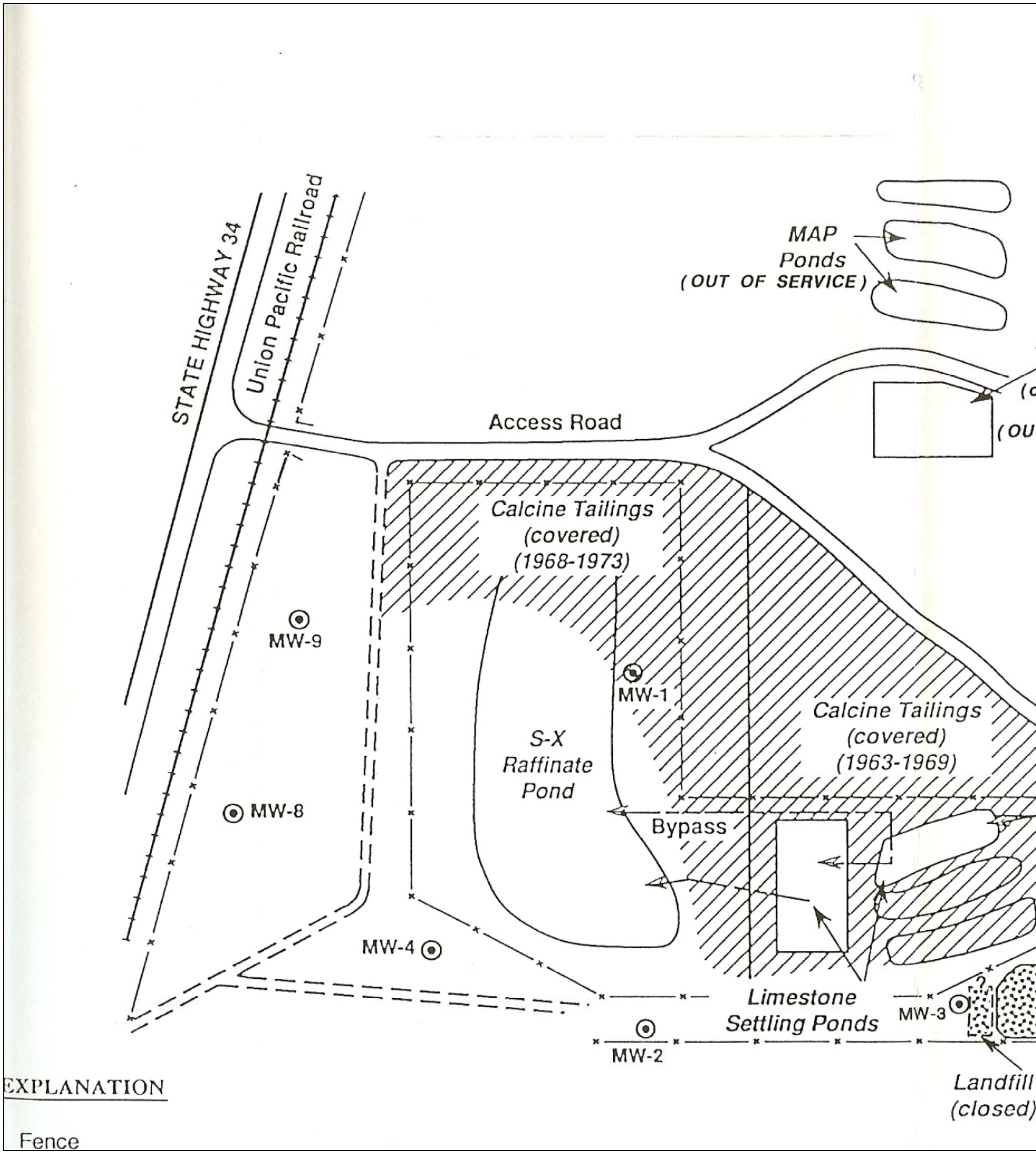
DRAWN BY J.S. BROWN, P.G.



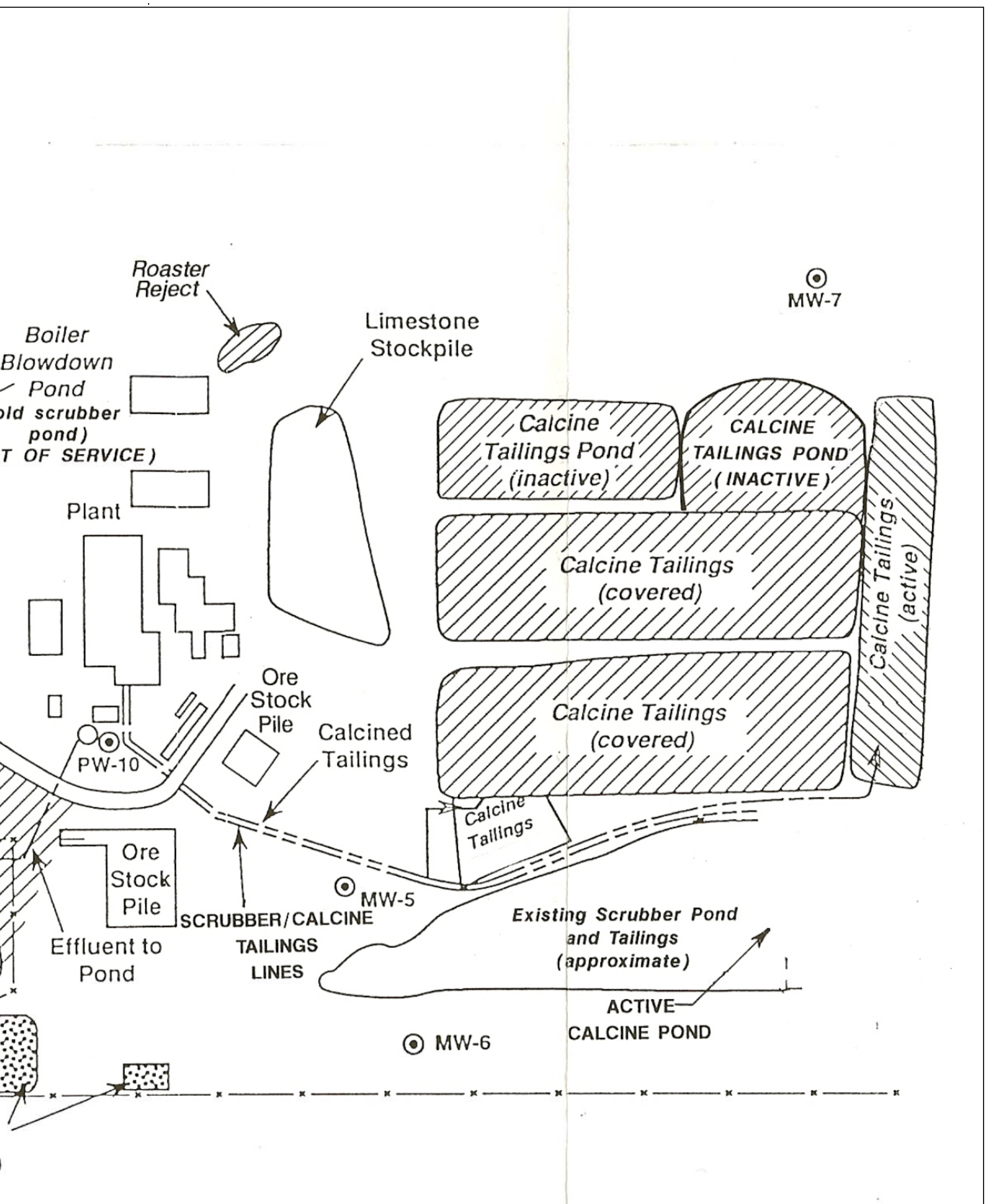
REMEDIAL INVESTIGATION REPORT, DAMES & MOORE, 1995

DRAFT REMEDY EVALUATION REPORT

TITLE	REMEDIAL INVESTIGATION COREHOLE, BORING, LYSIMETER AND MONITOR WELL LOCATIONS			
DRAWN BY J.S.BROWN P.G.	SIZE A	CAGE CODE	DWG NO	REV 1
DATE: 2/14/09	SCALE		SHEET	FIGURE 1-5



REFERENCE: DAMES & MOORE, 1995

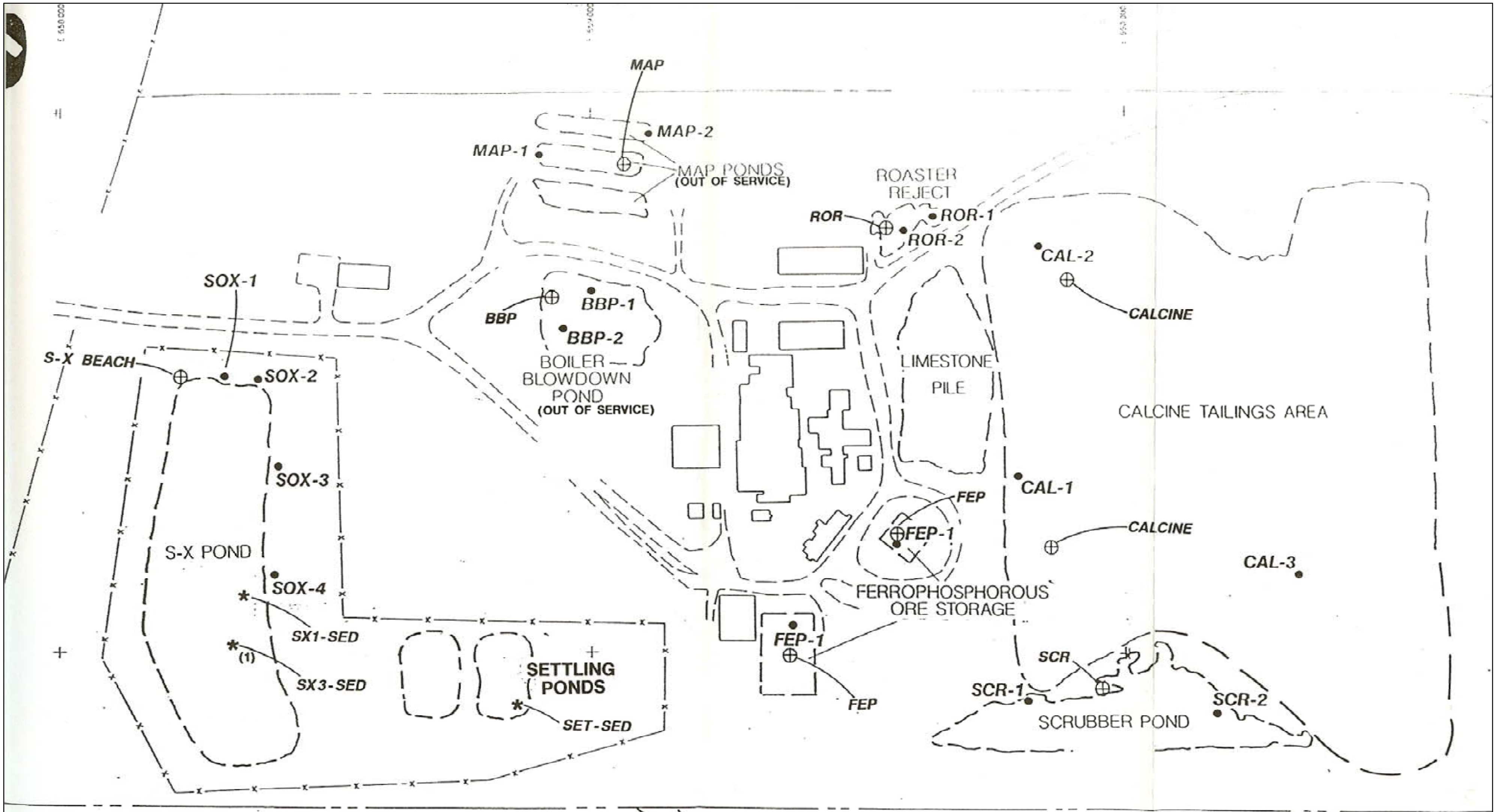


TRONOX SODA SPRINGS IDAHO
DRAFT REMEDY EVALUATION REPORT

TITLE

HISTORIC SOLID SOURCES AND IMPOUNDMENTS

4/14/08	SIZE B	CAGE CODE	DWG NO	REV
DRAWN BY J.S. BROWN, P.G.	SCALE		SHEET **FIGURE 1-4**	



REMEDIAL INVESTIGATION REPORT, DAMES & MOORE, 1995

DRAWN BY J.S.BROWN P.G.

DATE: 2/14/09

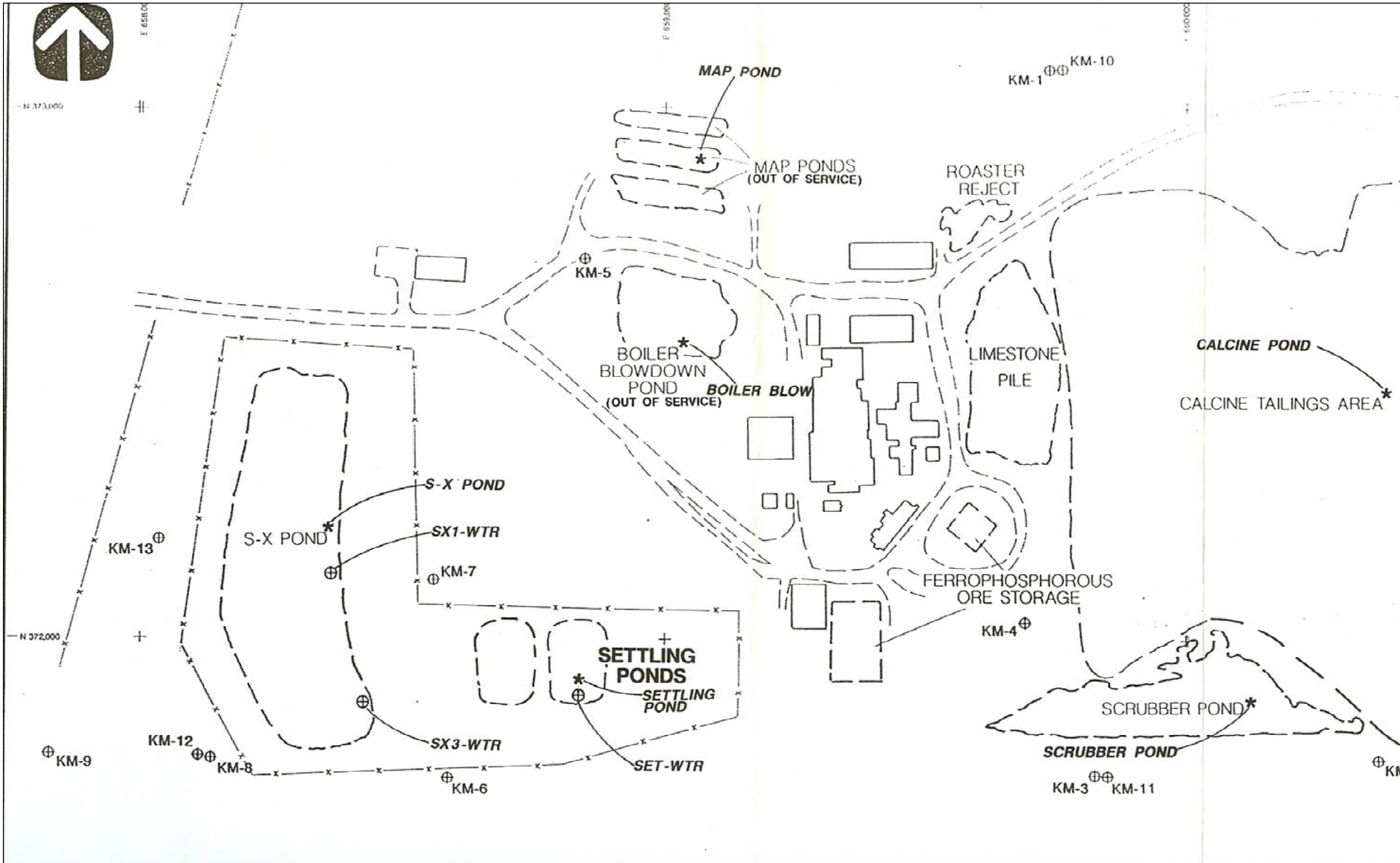
DRAFT REMEDY EVALUATION REPORT

TITLE

LOCATION OF SOLID SOURCE AND SEDIMENT SAMPLES

SIZE	CAGE CODE	DWG NO	REV
A			1

SCALE		SHEET	FIGURE 1-6



REMEDIAL INVESTIGATION REPORT, DAMES & MOORE, 1995

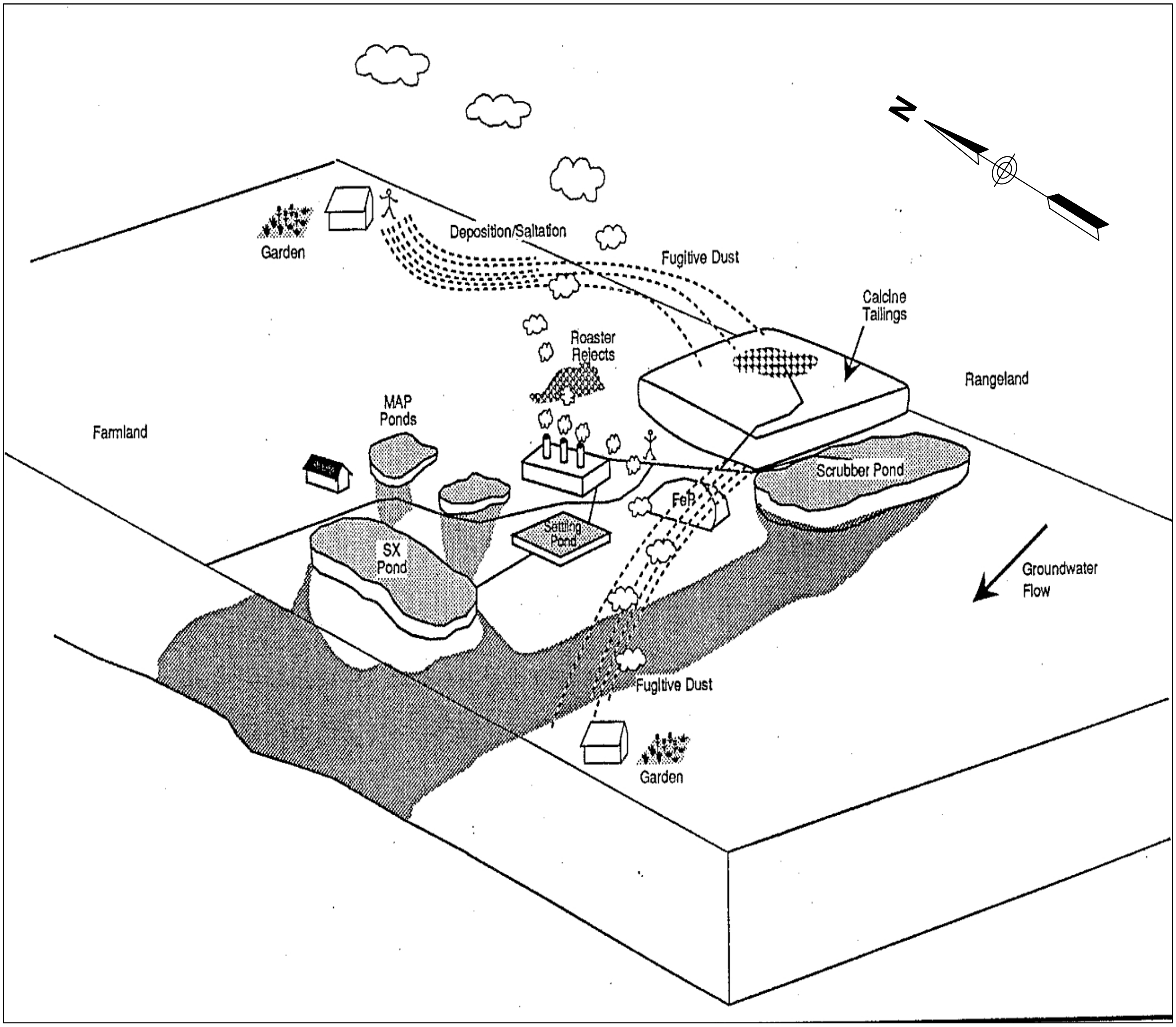
DRAWN BY J.S.BROWN P.G.

DATE: 2/14/09

TITLE

LOCATION OF SURFACE IMPOUNDMENT AND WATER SAMPLE LOCATIONS

SIZE	CAGE CODE	DWG NO	REV
A			1
SCALE		SHEET	FIGURE 1-7



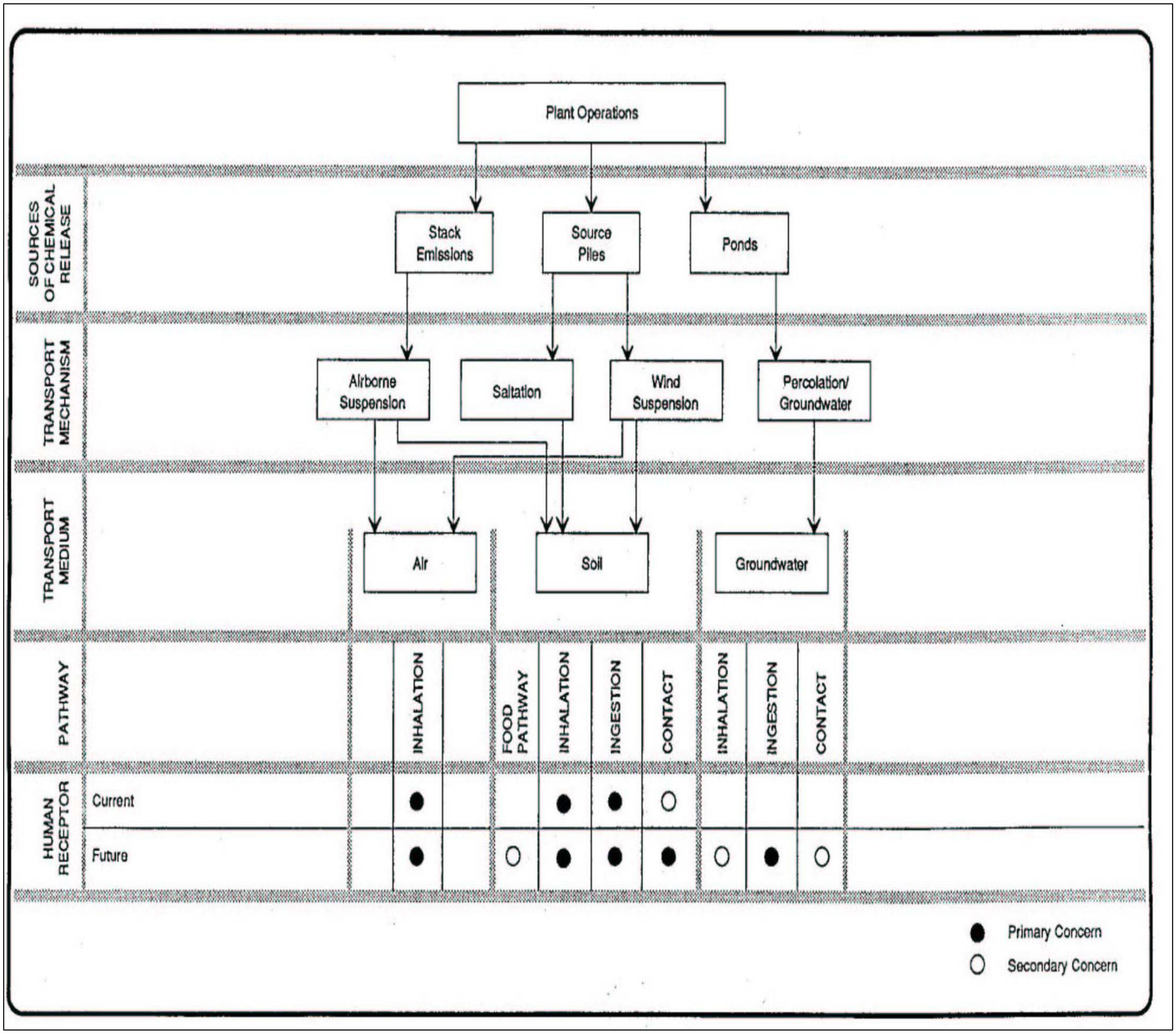
REFERENCE:SAIC/EPA, OCTOBER 1993

DRAFT REMEDY EVALUATION REPORT

RISK ASSESSMENT CONCEPTUAL SITE MODEL

TRONOX
SODA SPRINGS, IDAHO

FIGURE 1-8



REFERENCE:SAIC/EPA, OCTOBER 1993

DRAFT REMEDY EVALUATION REPORT

RISK ASSESSMENT ENVIRONMENTAL PATHWAY MODEL

TRONOX
SODA SPRINGS, IDAHO

FIGURE 1-9

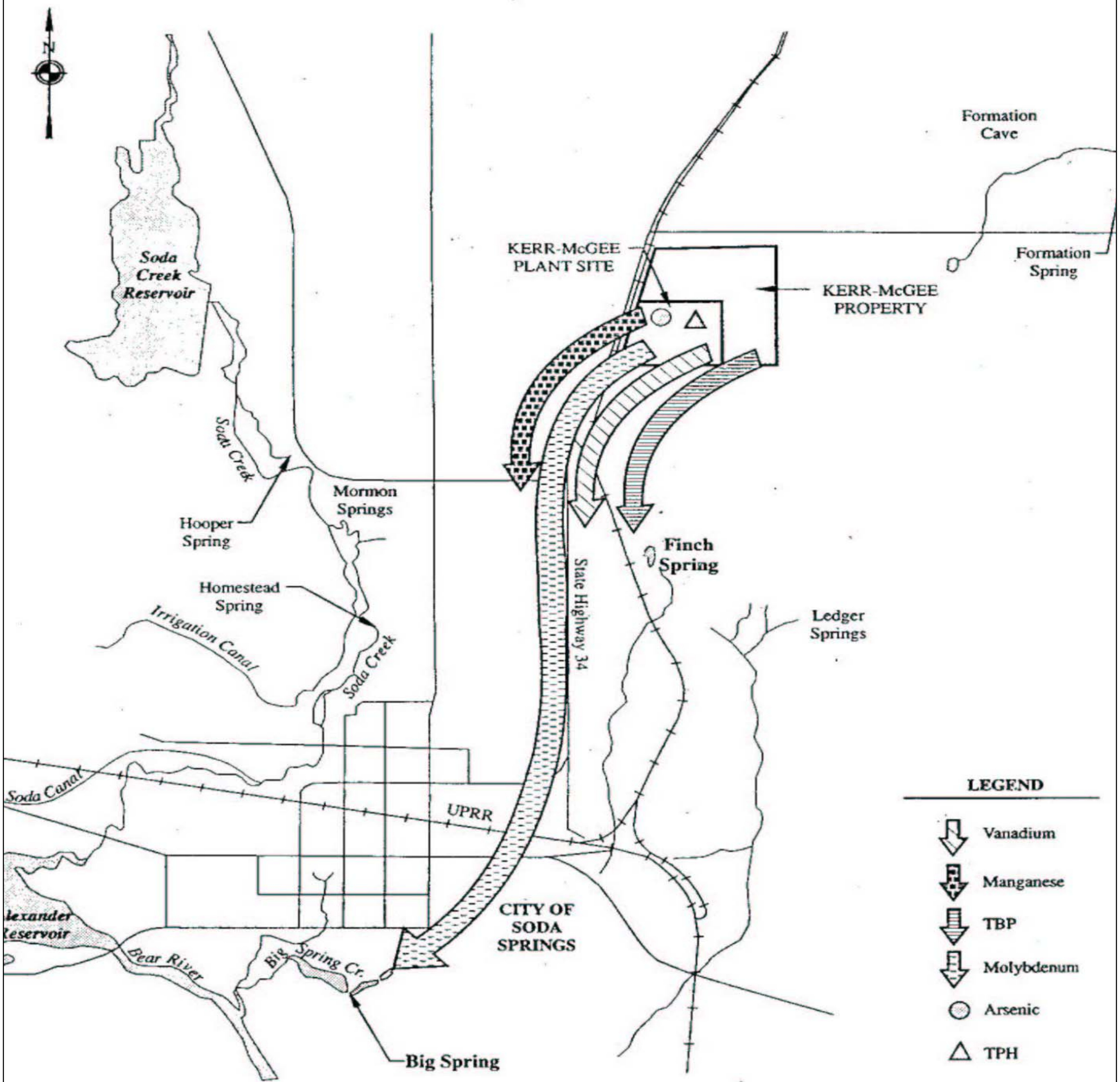


FIGURE 9
APPROXIMATE DIRECTION OF GROUNDWATER FLOW AND EXTENT OF GROUNDWATER CONTAMINATION AT LEVELS OF CONCERN FROM KERR-McGEE

REFERENCE:SAIC/EPA, 1996

DRAFT REMEDY EVALUATION REPORT

CONCEPTUAL SITE MODEL GROUND WATER PATHWAY RECORD OF DECISION 1996

TRONOX
SODA SPRINGS, IDAHO

FIGURE 1-10

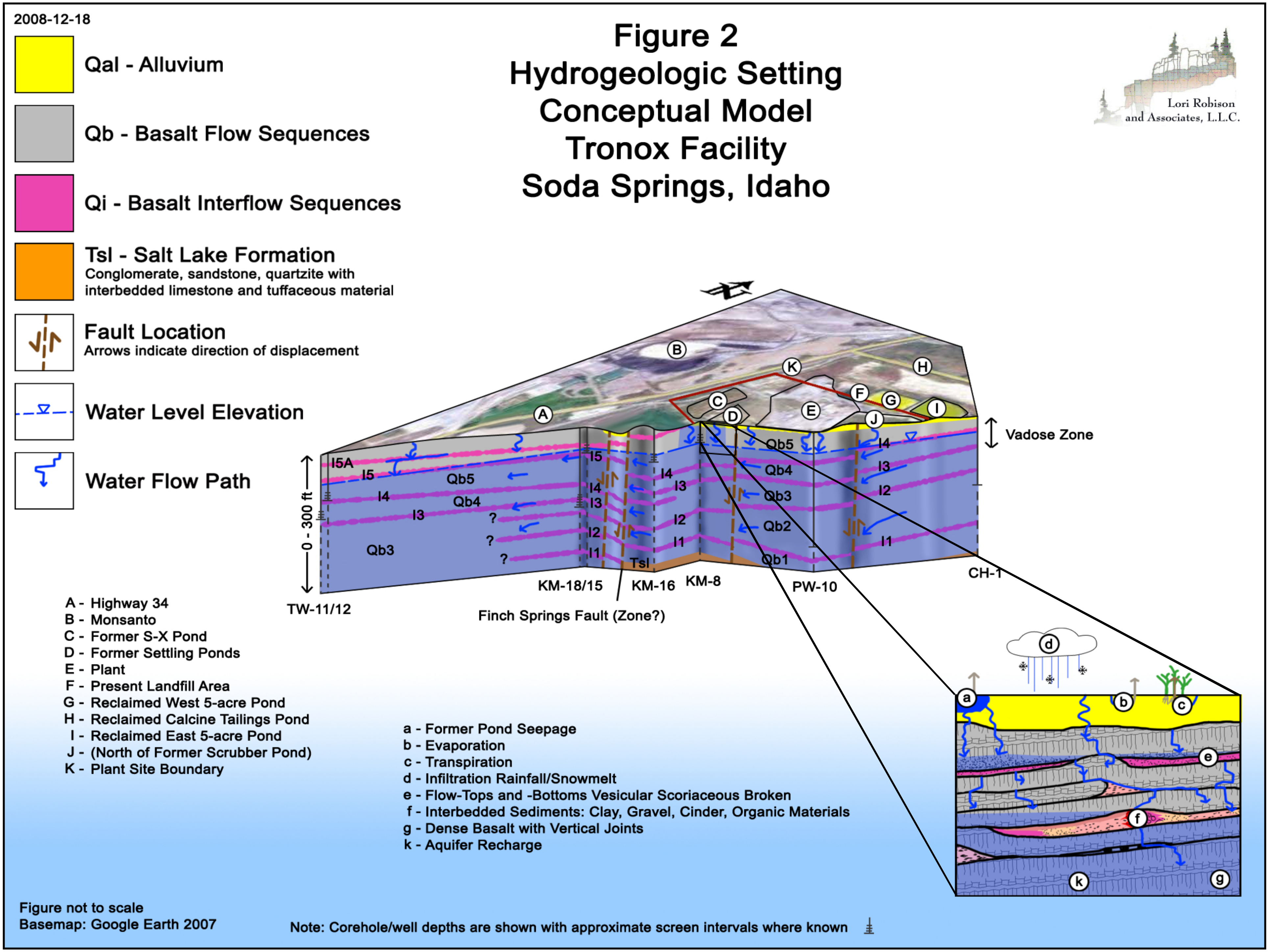

2008-12-18
Figure 2
Hydrogeologic Setting
Conceptual Model
Tronox Facility
Soda Springs, Idaho
Lori Robison and Associates, L.L.C.
Qal - Alluvium
Qb - Basalt Flow Sequences
Qi - Basalt Interflow Sequences
Tsl - Salt Lake Formation
Conglomerate, sandstone, quartzite with interbedded limestone and tuffaceous material
Fault Location
Arrows indicate direction of displacement
Water Level Elevation
Water Flow Path
Vadose Zone
0 - 300 ft
TW-11/12
KM-18/15
KM-16
KM-8
PW-10
CH-1
Finch Springs Fault (Zone?)
I5A
I5
I4
I3
I2
I1
Qb5
Qb4
Qb3
Qb2
Qb1
Tsl
A - Highway 34
B - Monsanto
C - Former S-X Pond
D - Former Settling Ponds
E - Plant
F - Present Landfill Area
G - Reclaimed West 5-acre Pond
H - Reclaimed Calcine Tailings Pond
I - Reclaimed East 5-acre Pond
J - (North of Former Scrubber Pond)
K - Plant Site Boundary
a - Former Pond Seepage
b - Evaporation
c - Transpiration
d - Infiltration Rainfall/Snowmelt
e - Flow-Tops and -Bottoms Vesicular Scoriaceous Broken
f - Interbedded Sediments: Clay, Gravel, Cinder, Organic Materials
g - Dense Basalt with Vertical Joints
k - Aquifer Recharge
Figure not to scale
Basemap: Google Earth 2007
Note: Corehole/well depths are shown with approximate screen intervals where known

FIGURE 1-11

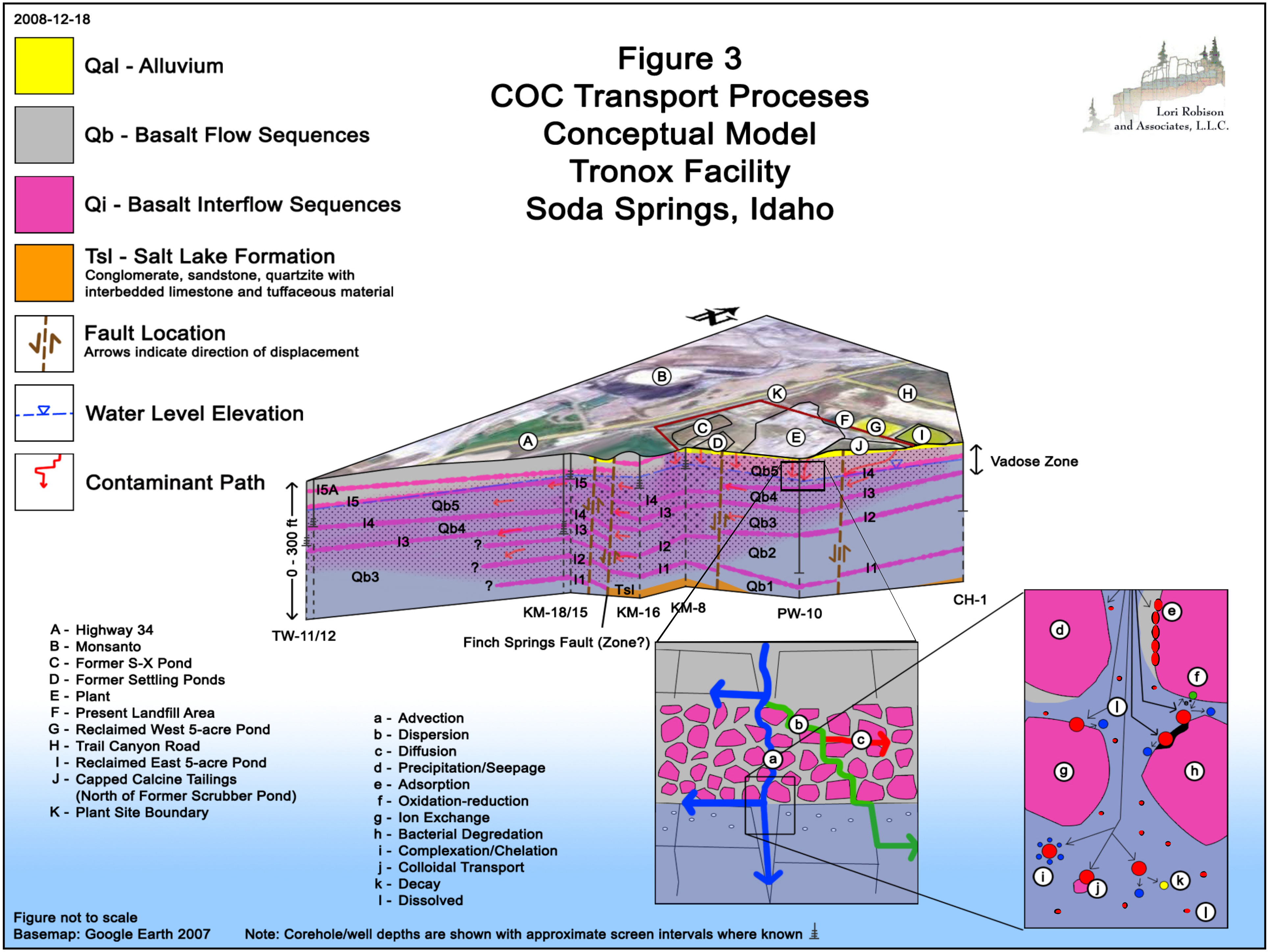
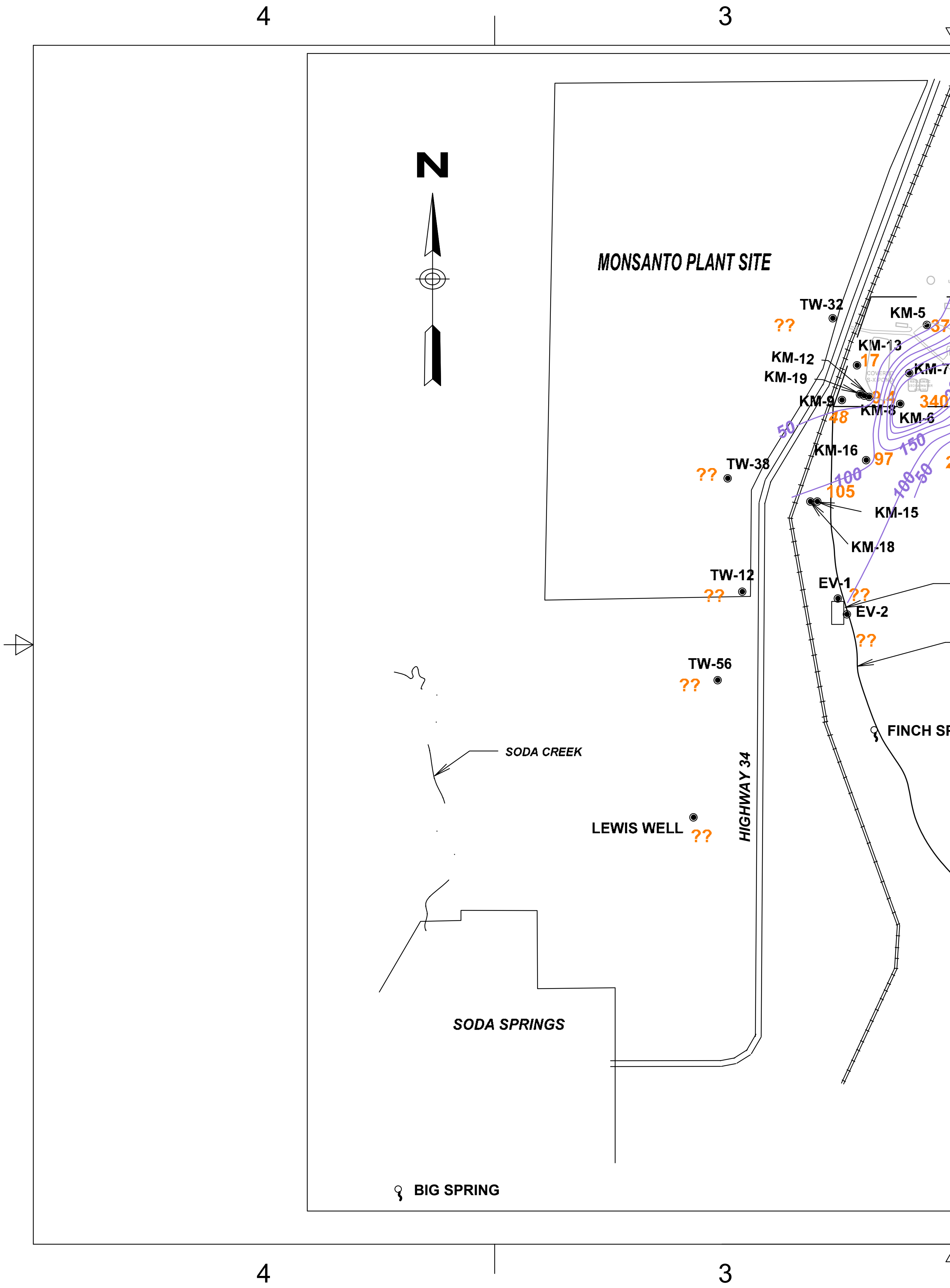
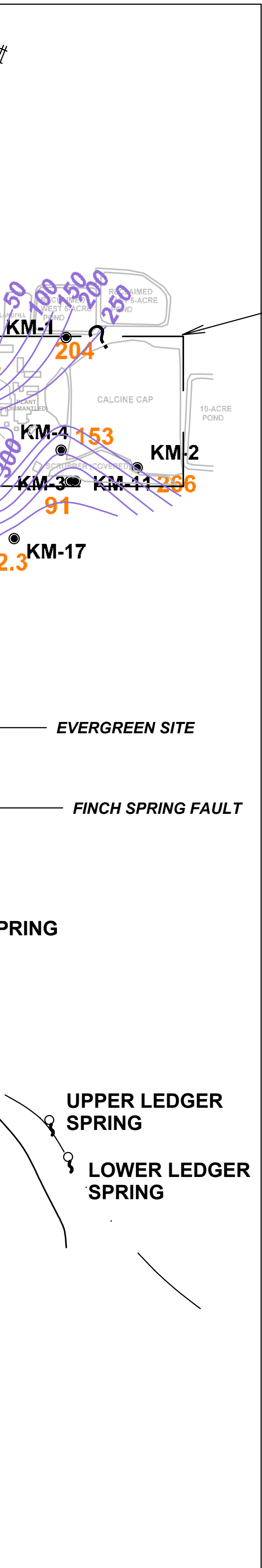

2008-12-18
Figure 3
COC Transport Proceses
Conceptual Model
Tronox Facility
Soda Springs, Idaho
Lori Robison and Associates, L.L.C.
Qal - Alluvium
Qb - Basalt Flow Sequences
Qi - Basalt Interflow Sequences
Tsl - Salt Lake Formation
Conglomerate, sandstone, quartzite with interbedded limestone and tuffaceous material
Fault Location
Arrows indicate direction of displacement
Water Level Elevation
Contaminant Path
Vadose Zone
0 - 300 ft
I5A
I5
I4
I3
I2
I1
Qb5
Qb4
Qb3
Qb2
Qb1
Tsl
?
TW-11/12
KM-18/15
KM-16
KM-8
PW-10
CH-1
Finch Springs Fault (Zone?)
A - Highway 34
B - Monsanto
C - Former S-X Pond
D - Former Settling Ponds
E - Plant
F - Present Landfill Area
G - Reclaimed West 5-acre Pond
H - Trail Canyon Road
I - Reclaimed East 5-acre Pond
J - Capped Calcine Tailings (North of Former Scrubber Pond)
K - Plant Site Boundary
a - Advection
b - Dispersion
c - Diffusion
d - Precipitation/Seepage
e - Adsorption
f - Oxidation-reduction
g - Ion Exchange
h - Bacterial Degredation
i - Complexation/Chelation
j - Colloidal Transport
k - Decay
l - Dissolved
Figure not to scale
Basemap: Google Earth 2007
Note: Corehole/well depths are shown with approximate screen intervals where known

FIGURE 1-12



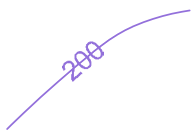
4
3
N
MONSANTO PLANT SITE
TW-32
??
KM-5
KM-13
17
KM-12
KM-19
KM-9
KM-8
KM-6
340
48
50
KM-16
97
TW-38
??
100
105
150
KM-15
KM-18
TW-12
??
EV-1
??
EV-2
??
TW-56
??
SODA CREEK
HIGHWAY 34
LEWIS WELL
??
SODA SPRINGS
BIG SPRING
4
3



TRONOX SITE

PLANT FACILITY BOUNDARY

KEY



INFERRED CONTOUR AND HYDRAULIC CONDUCTIVITY ISOPLETH

MONITOR WELL LOCATION AND ESTIMATED HYDRAULIC CONDUCTIVITY IN FEET/DAY

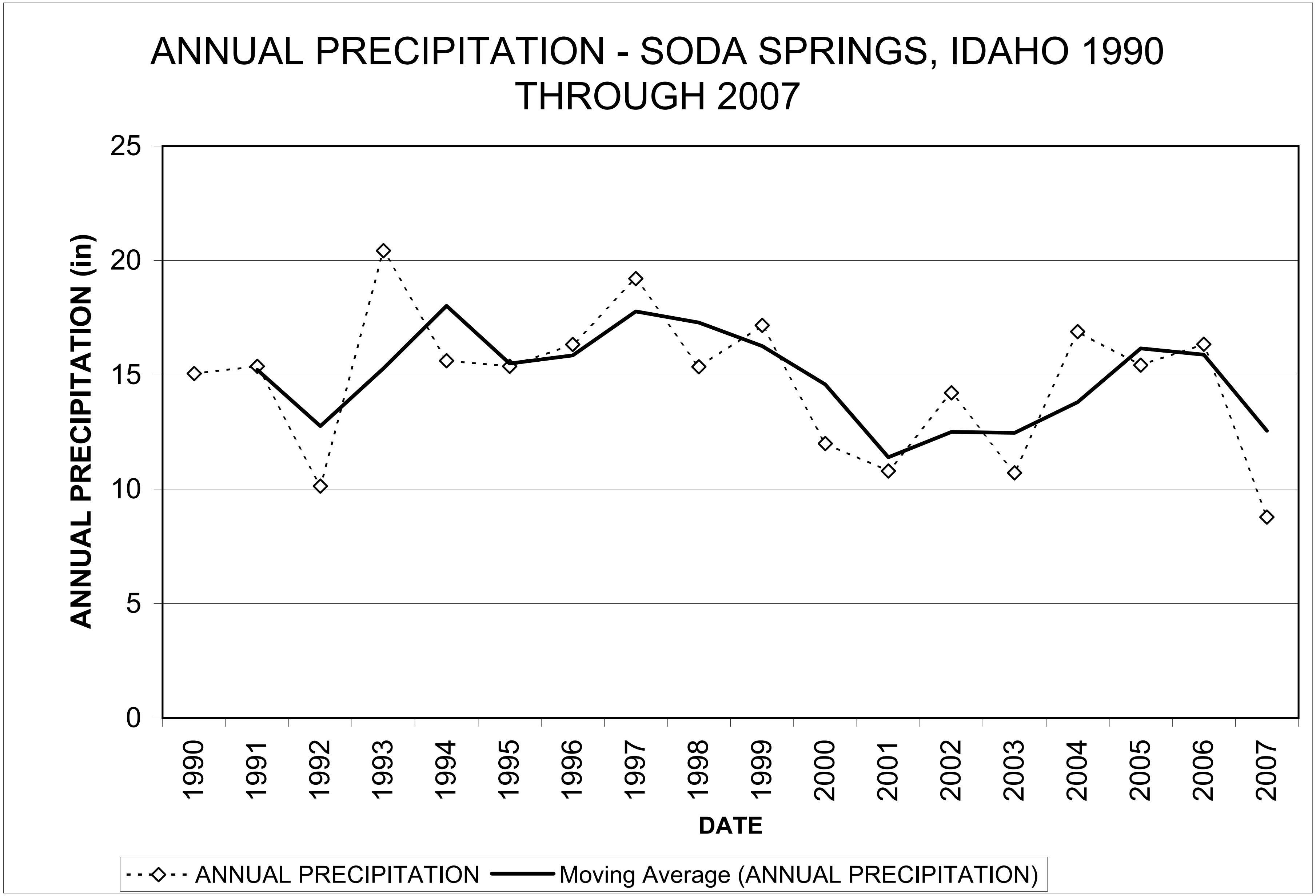
SCALE IN FEET

0 750 1500 3000

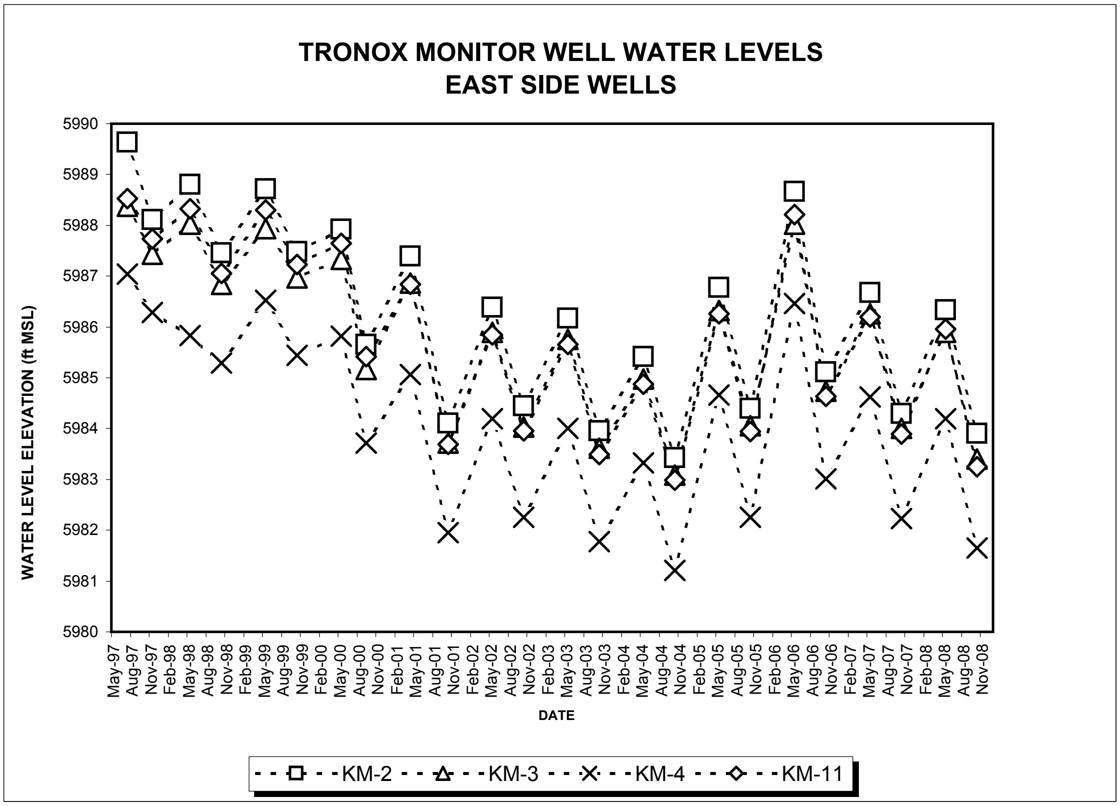
DRAFT REMEDY EVALUATION

~~ADDENDUM 1 WORK PLAN~~

TITLE	**DISTRIBUTION OF SHALLOW AQUIFER HYDRAULIC CONDUCTIVIY**		
SIZE B	CAGE CODE	DWG NO **WATERSAMPLELOCATIONS.TCW**	REV **0**
SCALE **AS SHOWN**		SHEET	**FIGURE 2-1**


ANNUAL PRECIPITATION - SODA SPRINGS, IDAHO 1990 THROUGH 2007
ANNUAL PRECIPITATION (in)
25
20
15
10
5
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
DATE
ANNUAL PRECIPITATION
Moving Average (ANNUAL PRECIPITATION)

WATER LEVELS VERSUS TIME
TRONOX ON-SITE WELLS
FOLLOWING LSE AND POND RECLAMATION



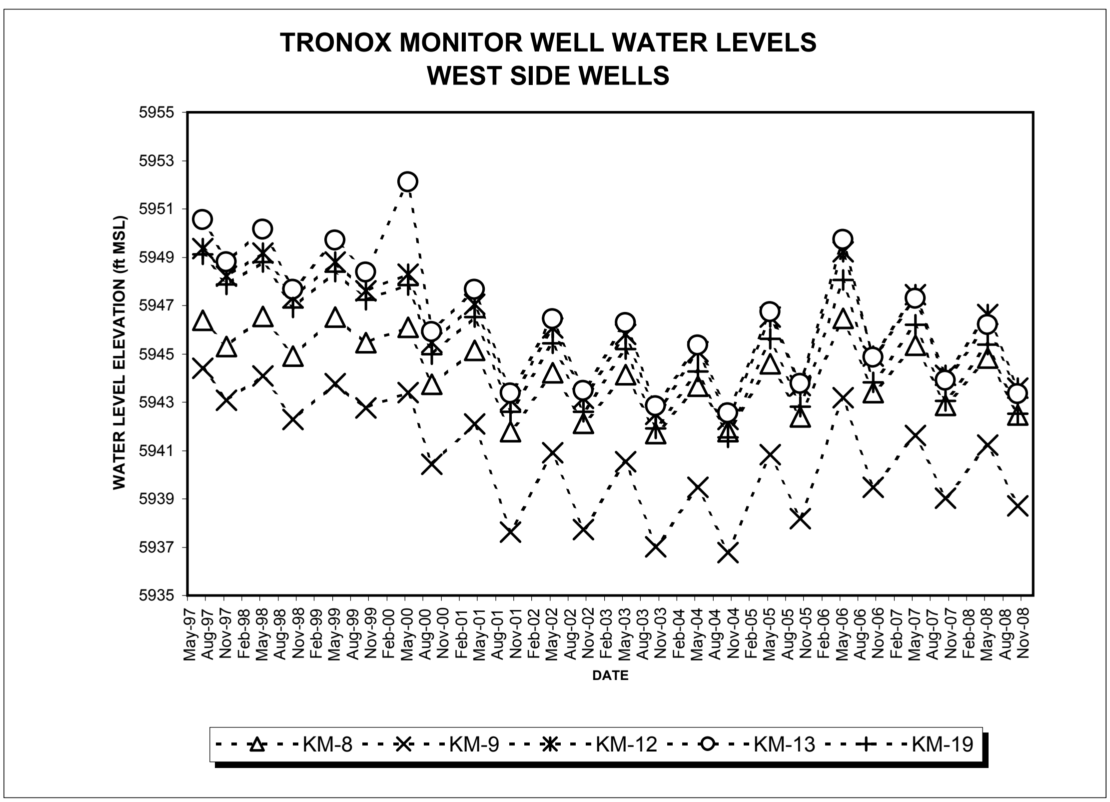
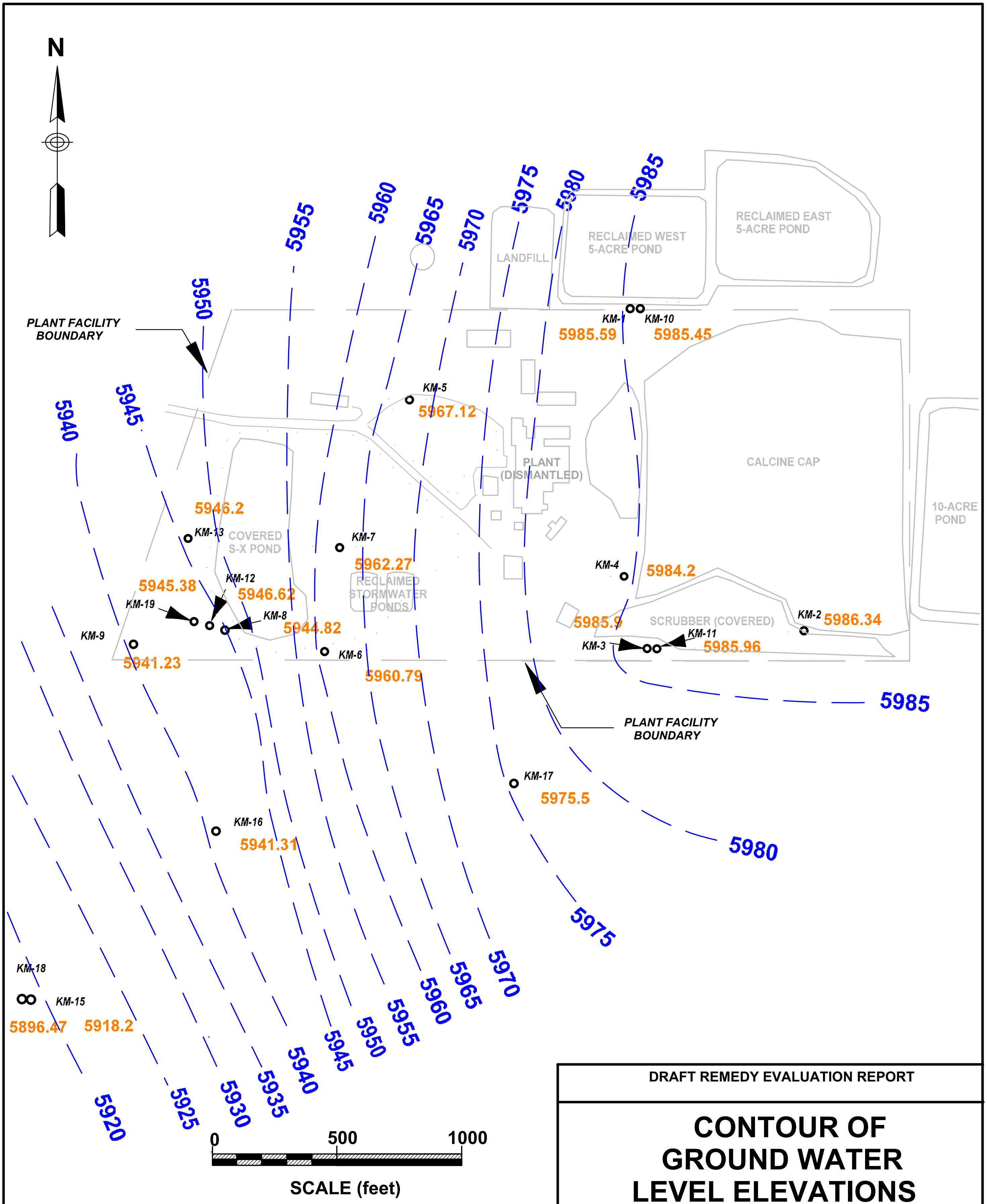


FIGURE 2-3



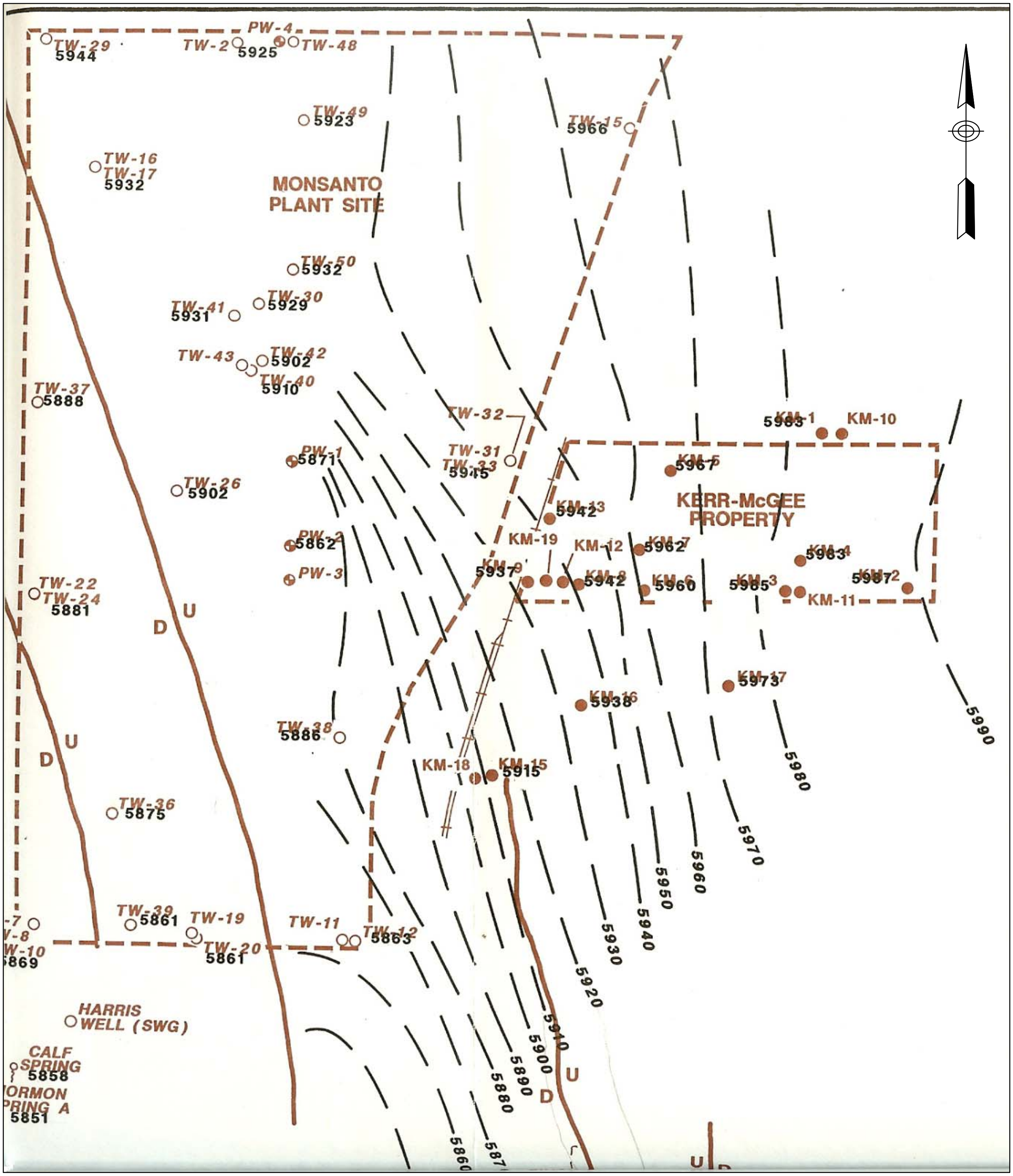
DRAFT REMEDY EVALUATION REPORT

CONTOUR OF GROUND WATER LEVEL ELEVATIONS MAY 2008

NOTE: CONTOURS BASED ON GROUND WATER LEVELS IN SHALLOW WELLS

TRONOX
SODA SPRINGS, IDAHO

FIGURE X-X 2-4



0 500 1000

SCALE (feet)

NOTE: CONTOURS BASED ON GROUND WATER LEVELS IN SHALLOW WELLS

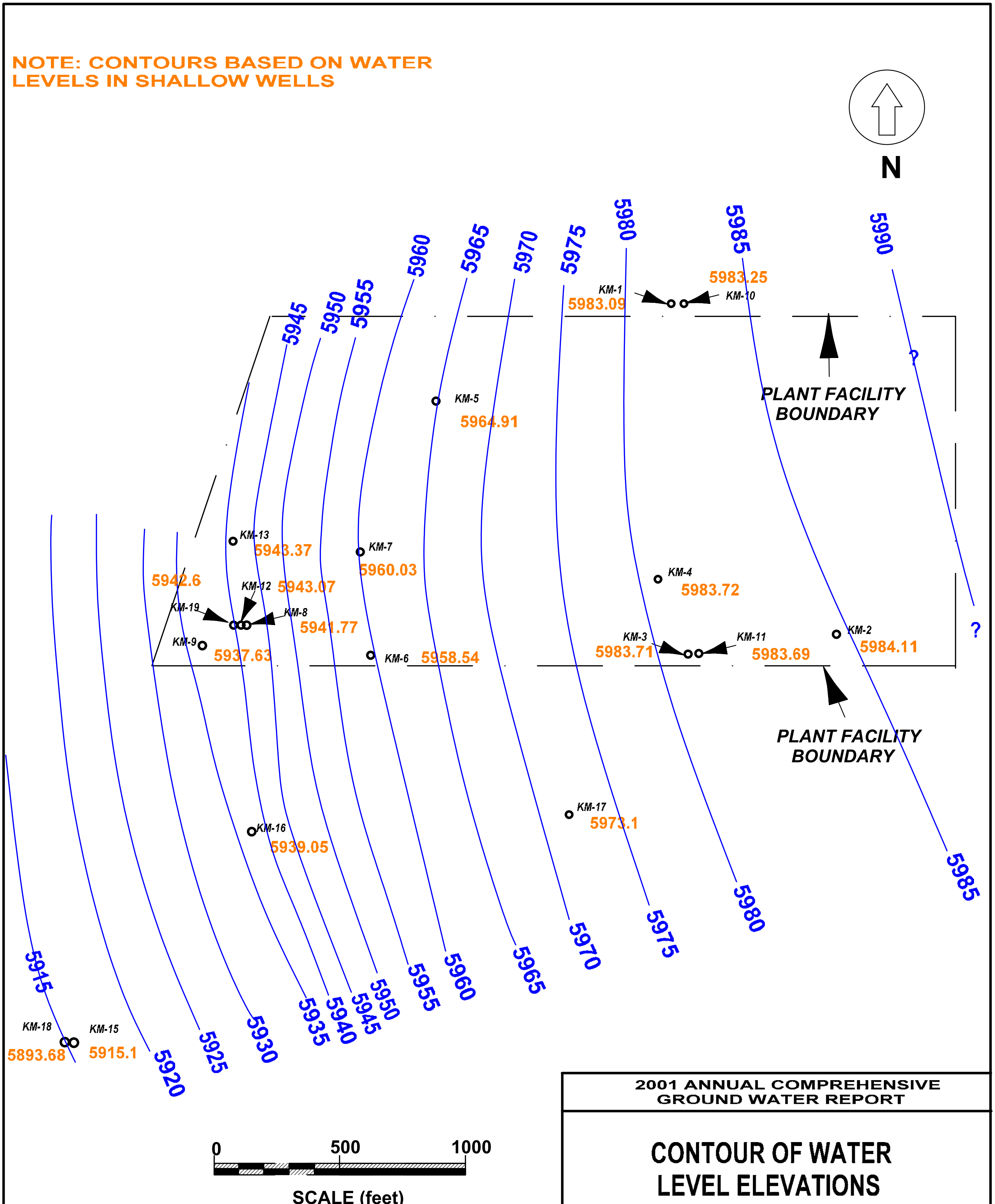
REFERENCE:DAMES & MOORE, 1995 RI REPORT

DRAFT REMEDY EVALUATION REPORT

CONTOUR OF GROUND WATER LEVEL ELEVATIONS NOVEMBER 1992

TRONOX
SODA SPRINGS, IDAHO

FIGURE 2-5

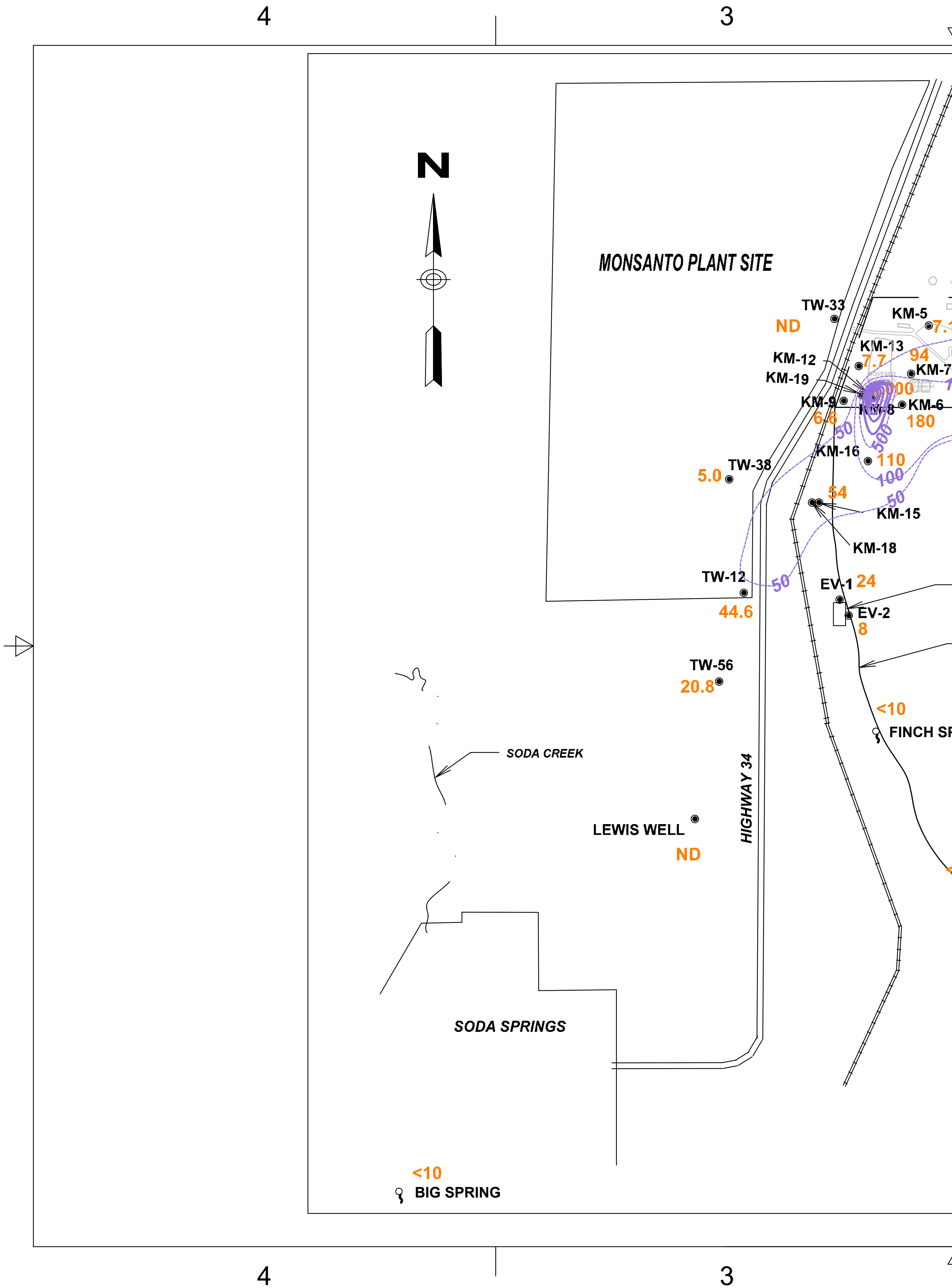


2001 ANNUAL COMPREHENSIVE GROUND WATER REPORT

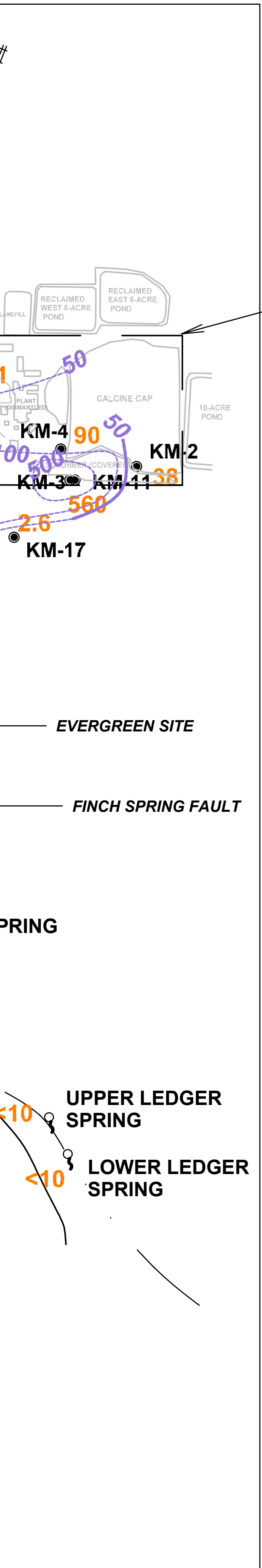
CONTOUR OF WATER LEVEL ELEVATIONS OCTOBER 2001

KERR-McGEE CHEMICAL LLC
SODA SPRINGS, IDAHO

FIGURE 2-6



4
3
N
MONSANTO PLANT SITE
TW-33
ND
KM-5
KM-13
7.7
94
KM-12
KM-19
KM-7
KM-9
KM-8
KM-6
6.6
180
50
500
KM-16
110
TW-38
5.0
100
54
50
KM-15
KM-18
TW-12
50
EV-1
24
44.6
EV-2
8
TW-56
20.8
<10
SODA CREEK
HIGHWAY 34
LEWIS WELL
ND
SODA SPRINGS
<10
BIG SPRING
4
3



KEY

INFERRED CONTOUR AND CONCENTRATION

MONITOR WELL LOCATION AND CONCENTRATION IN UG/L

SCALE IN FEET

0 750 1500 3000

NOTES:

CONCENTRATIONS ARE IN UG/L
CONTOURS ARE BASED ON CONCENTRATIONS IN SHALLOW AQUIFER.

RBC FOR MANGANESE IS 180 UG/L

DRAFT REMEDY EVALUATION REPORT

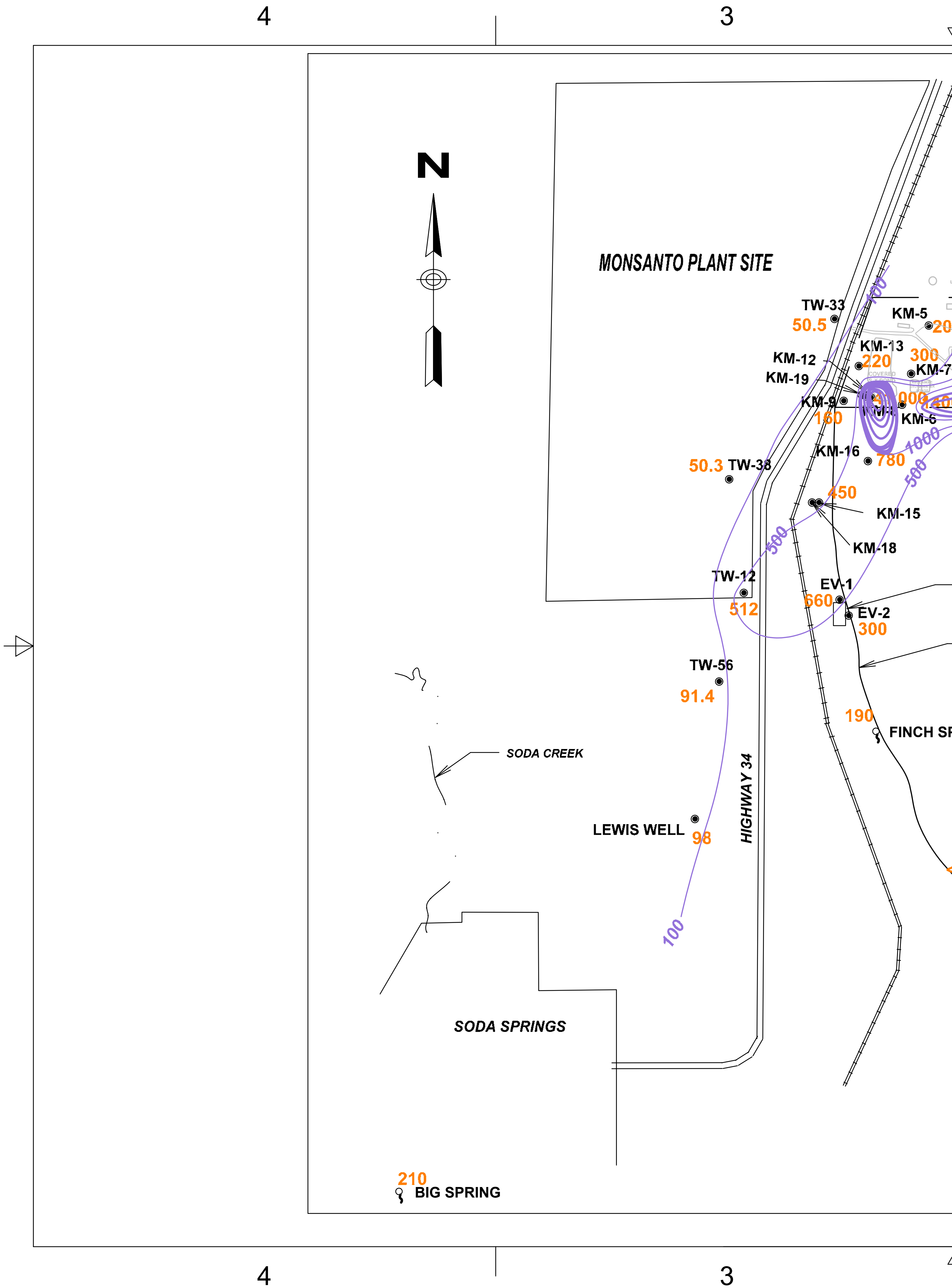
MONITOR WELL NETWORK EVALUATION

TITLE

GROUND AND SURFACE WATER MANGANESE CONCENTRATIONS MAY 2007

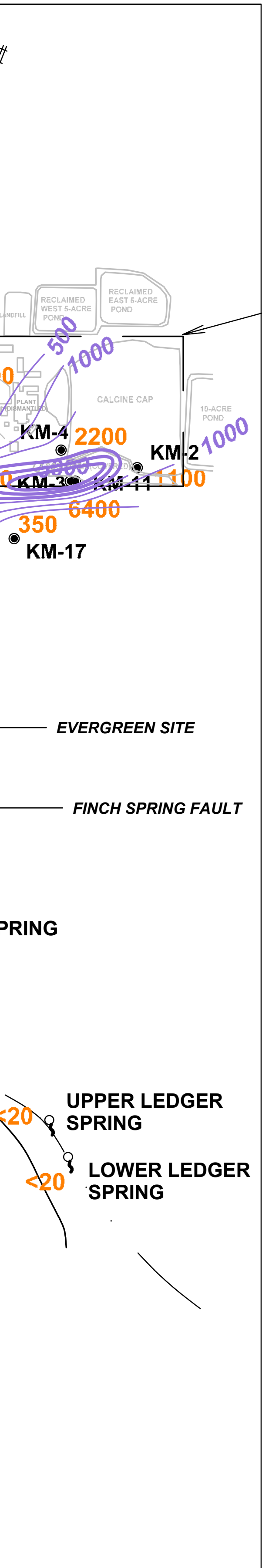
SIZE	CAGE CODE	DWG NO	REV
B		WATERSAMPLELOCATIONS.TCW	0

SCALE		SHEET
AS SHOWN		FIGURE 2-7



4
3
N
MONSANTO PLANT SITE
TW-33
50.5
KM-5
KM-13
220
300
KM-12
KM-19
KM-9
160
KM-6
KM-16
780
1000
500
100
50.3
TW-38
450
KM-15
KM-18
TW-12
512
EV-1
660
EV-2
300
TW-56
91.4
190
SODA CREEK
HIGHWAY 34
LEWIS WELL
98
SODA SPRINGS
210
BIG SPRING
4
3

2 1



TRONOX SITE

PLANT FACILITY BOUNDARY

KEY

200 INFERRED CONTOUR AND CONCENTRATION

350 KM-17 MONITOR WELL LOCATION AND CONCENTRATION IN UG/L

SCALE IN FEET

0 750 1500 3000

NOTES:

CONCENTRATIONS ARE IN UG/L
CONTOURS ARE BASED ON CONCENTRATIONS IN SHALLOW AQUIFER.

RBC FOR MOLYBDENUM IS 180 UG/L

MONITOR WELL NETWORK EVALUATION

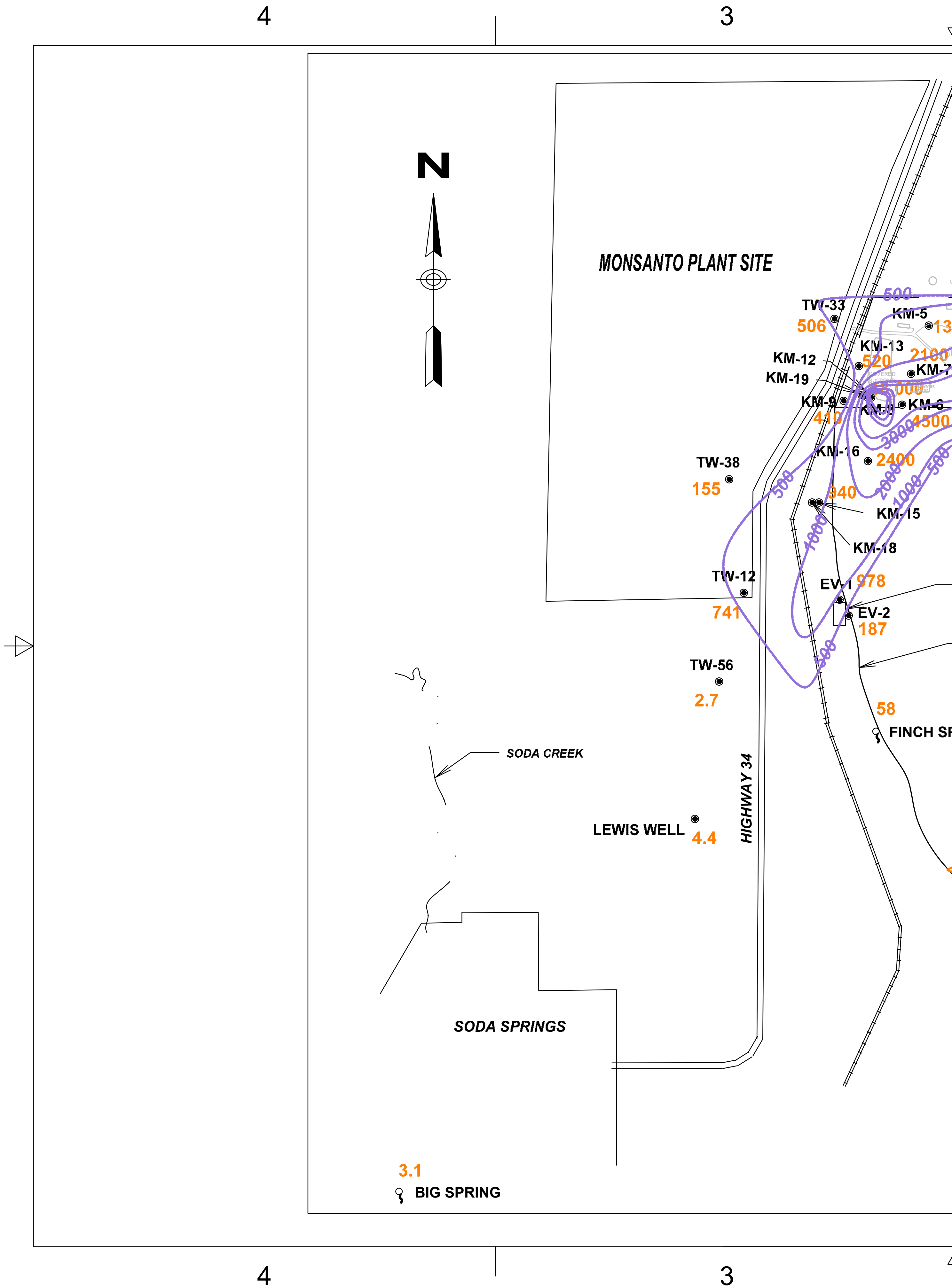
TITLE

GROUND AND SURFACE WATER MOLYBDENUM CONCENTRATIONS MAY 2007

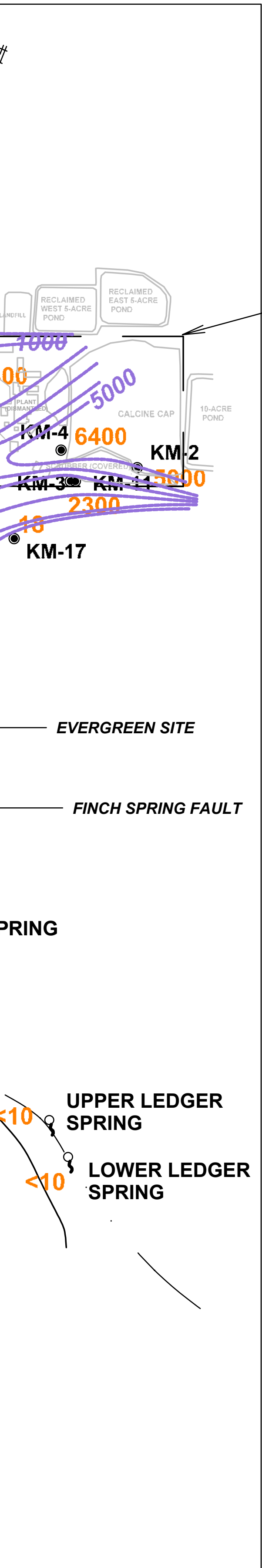
SIZE	CAGE CODE	DWG NO	REV
B		WATERSAMPLELOCATIONS.TCW	0

SCALE		SHEET
AS SHOWN		FIGURE 2-8

2 1


4
3
N
MONSANTO PLANT SITE
TW-33
506
KM-5
KM-13
520
2100
KM-12
KM-19
KM-9
410
KM-6
4500
KM-16
2400
TW-38
155
940
KM-15
KM-18
TW-12
741
EV-1
978
EV-2
187
TW-56
2.7
58
SODA CREEK
HIGHWAY 34
LEWIS WELL
4.4
SODA SPRINGS
3.1
BIG SPRING
500
1000
2000
3000
4

2 1



TRONOX SITE

PLANT FACILITY BOUNDARY

KEY

500 INFERRED CONTOUR AND CONCENTRATION

18
KM-17 MONITOR WELL LOCATION AND CONCENTRATION IN UG/L

SCALE IN FEET

0 750 1500 3000

NOTES:

CONCENTRATIONS ARE IN UG/L
CONTOURS ARE BASED ON CONCENTRATIONS IN SHALLOW AQUIFER.

RBC FOR VANADIUM IS 260 UG/L

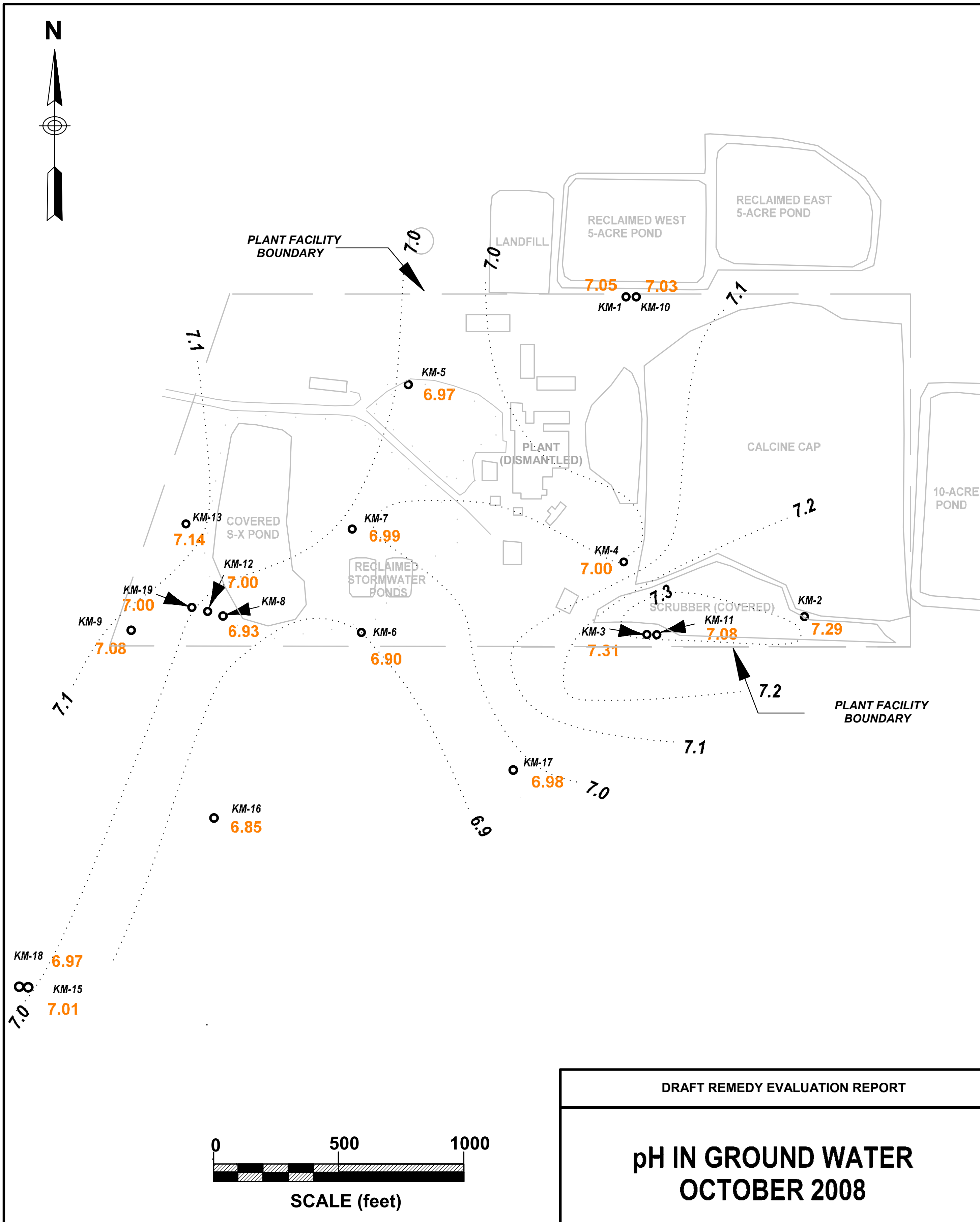
* MONSANTO DATA OBTAINED BY GOLDER BETWEEN JUNE 19 AND JUNE 27, 2007

MONITOR WELL NETWORK EVALUATION

TITLE **GROUND AND SURFACE WATER VANADIUM CONCENTRATIONS MAY 2007***

SIZE	CAGE CODE	DWG NO	REV
B		WATERSAMPLELOCATIONS.TCW	0
SCALE AS SHOWN		SHEET FIGURE 2-9	

2 1



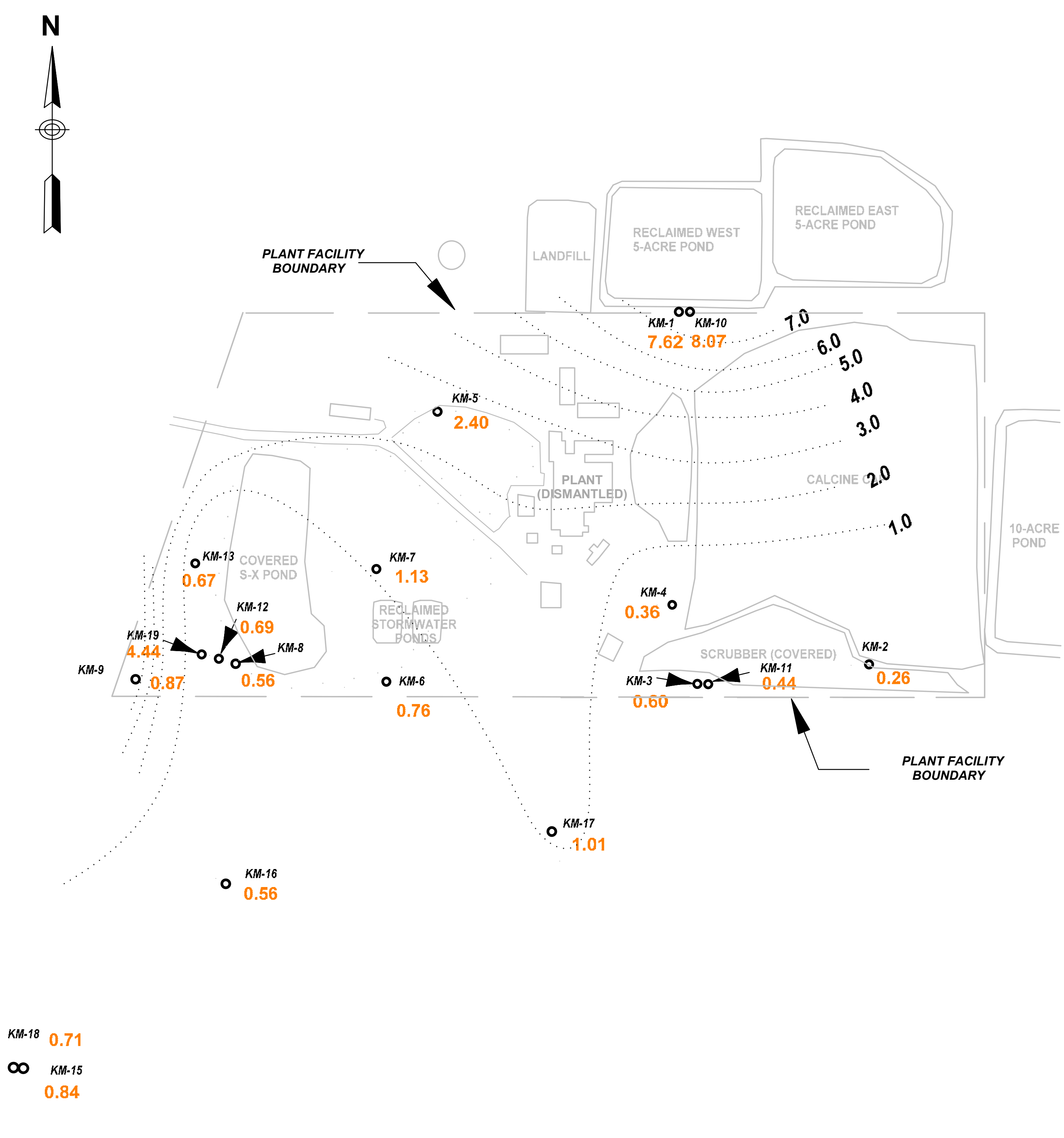
NOTE: CONCENTRATIONS ARE IN pH units.
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS IN SHALLOW AQUIFER.

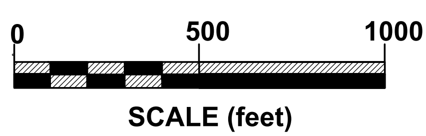
DRAFT REMEDY EVALUATION REPORT

pH IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

FIGURE 2-10





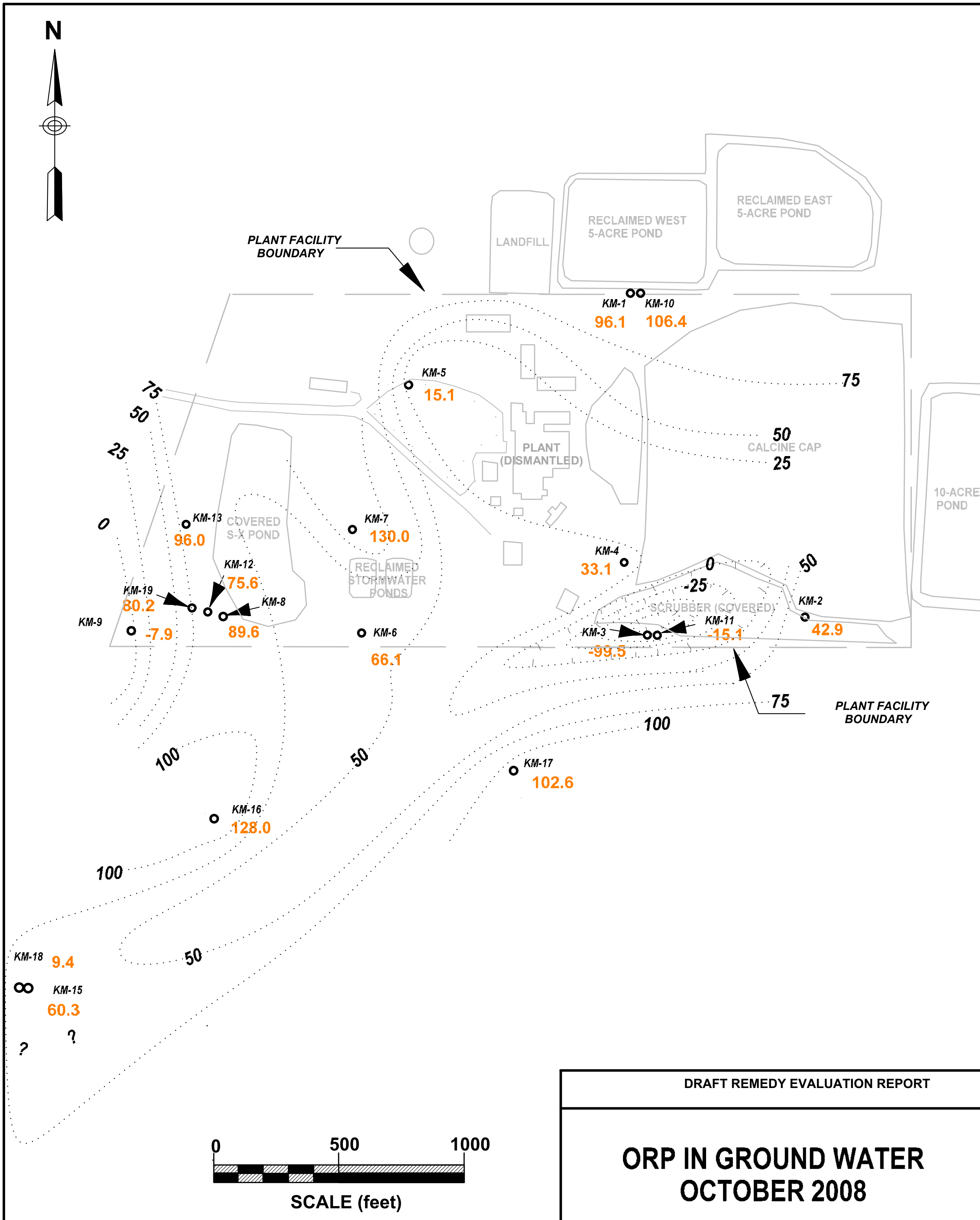
NOTE: CONCENTRATIONS ARE IN DO (MG/L).
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS
IN SHALLOW AQUIFER.

DRAFT REMEDY EVALUATION REPORT

DISSOLVED OXYGEN IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

FIGURE ~~4-1~~ 2-11



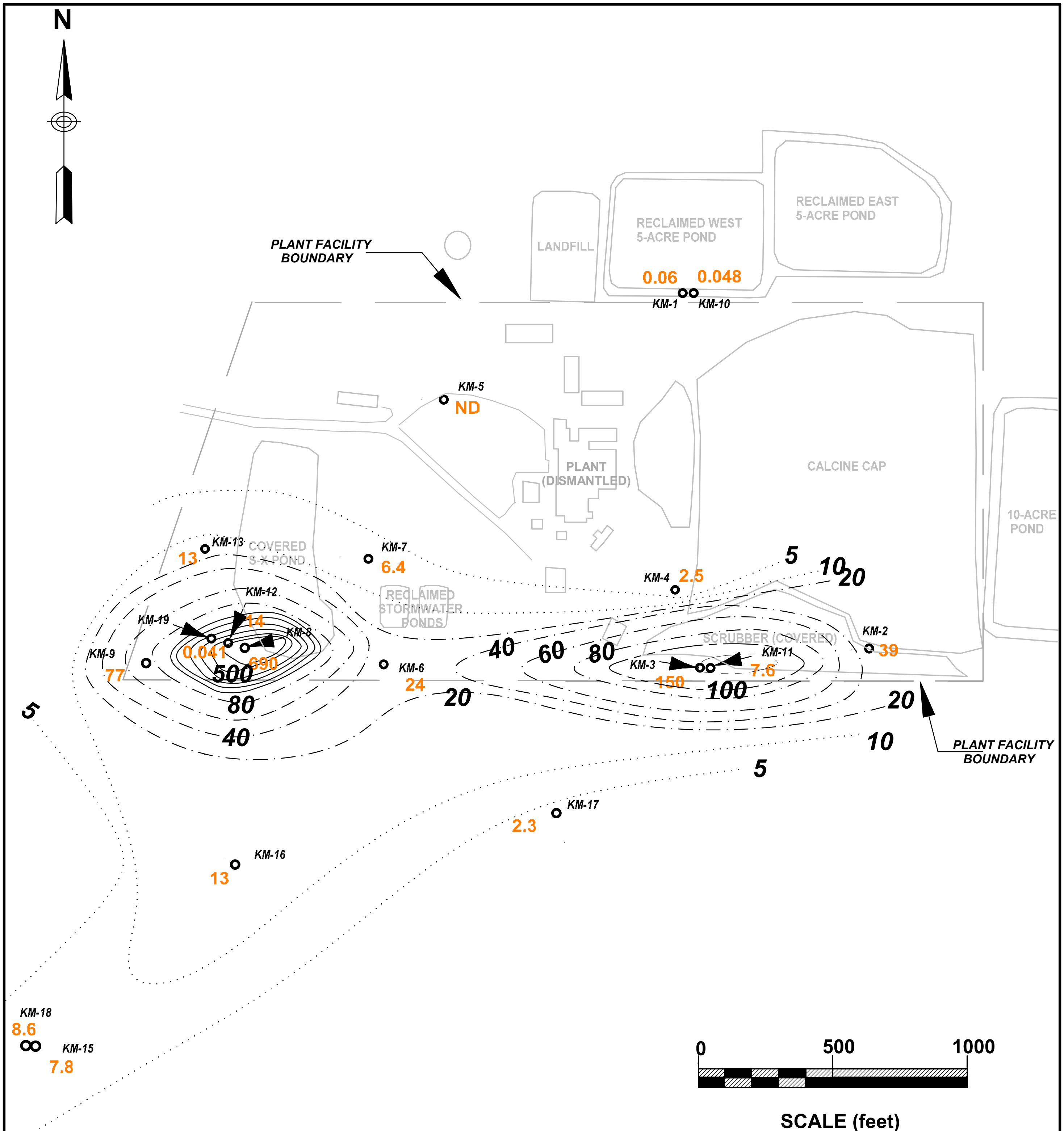
NOTE: CONCENTRATIONS ARE IN mV
CONCENTRATIONS BASED ON OBSERVED POTENTIALS IN SHALLOW AQUIFER.

DRAFT REMEDY EVALUATION REPORT

ORP IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

FIGURE ~~4-1~~ 2-12



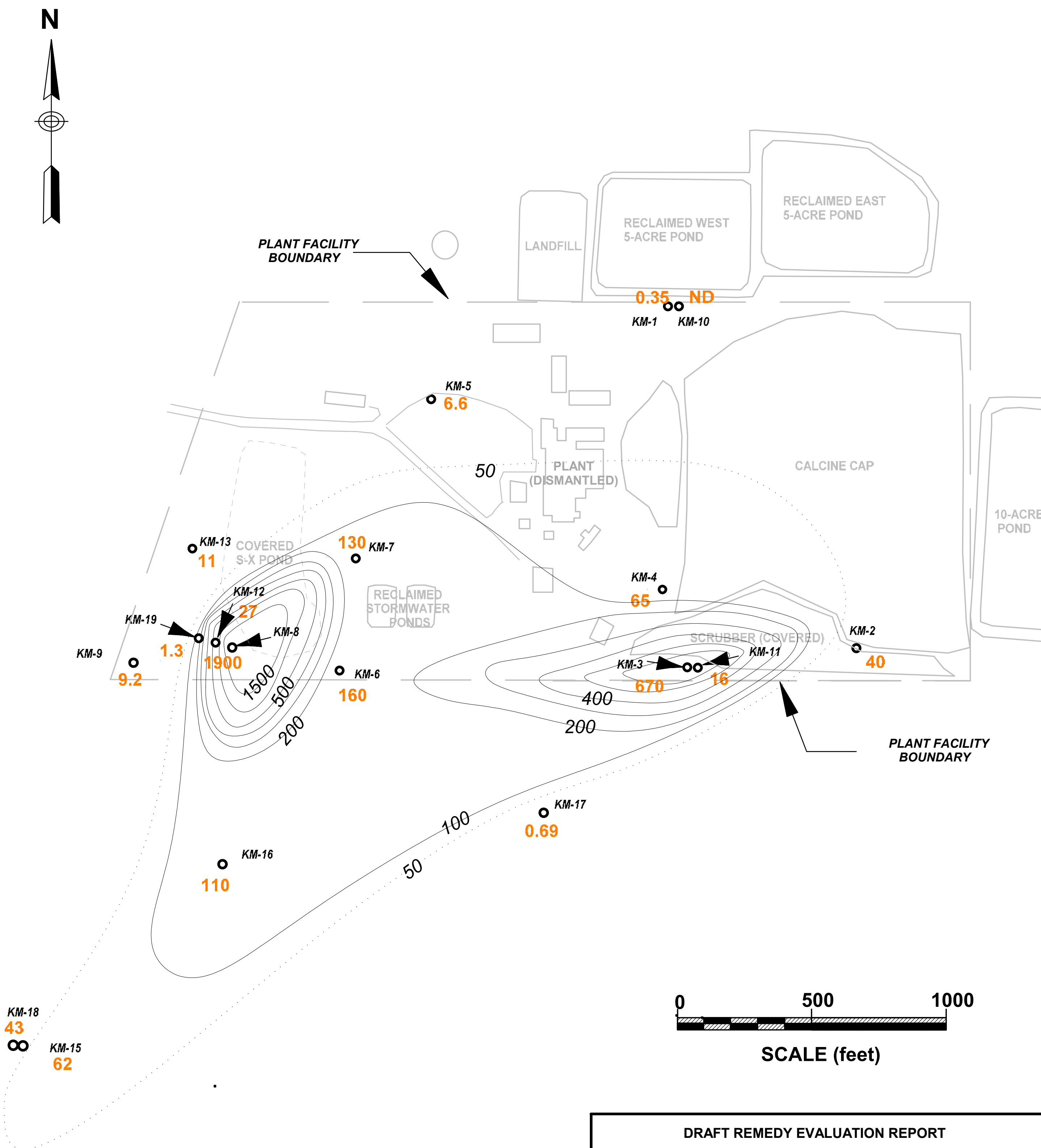
DRAFT REMEDY EVALUATION REPORT

CONCENTRATIONS OF AMMONIUM IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

FIGURE 4-5 2-13

NOTE: CONCENTRATIONS ARE IN MG/L.
CONCENTRATIONS BASED ON OBSERVED CONCENTRATIONS IN SHALLOW AQUIFER.



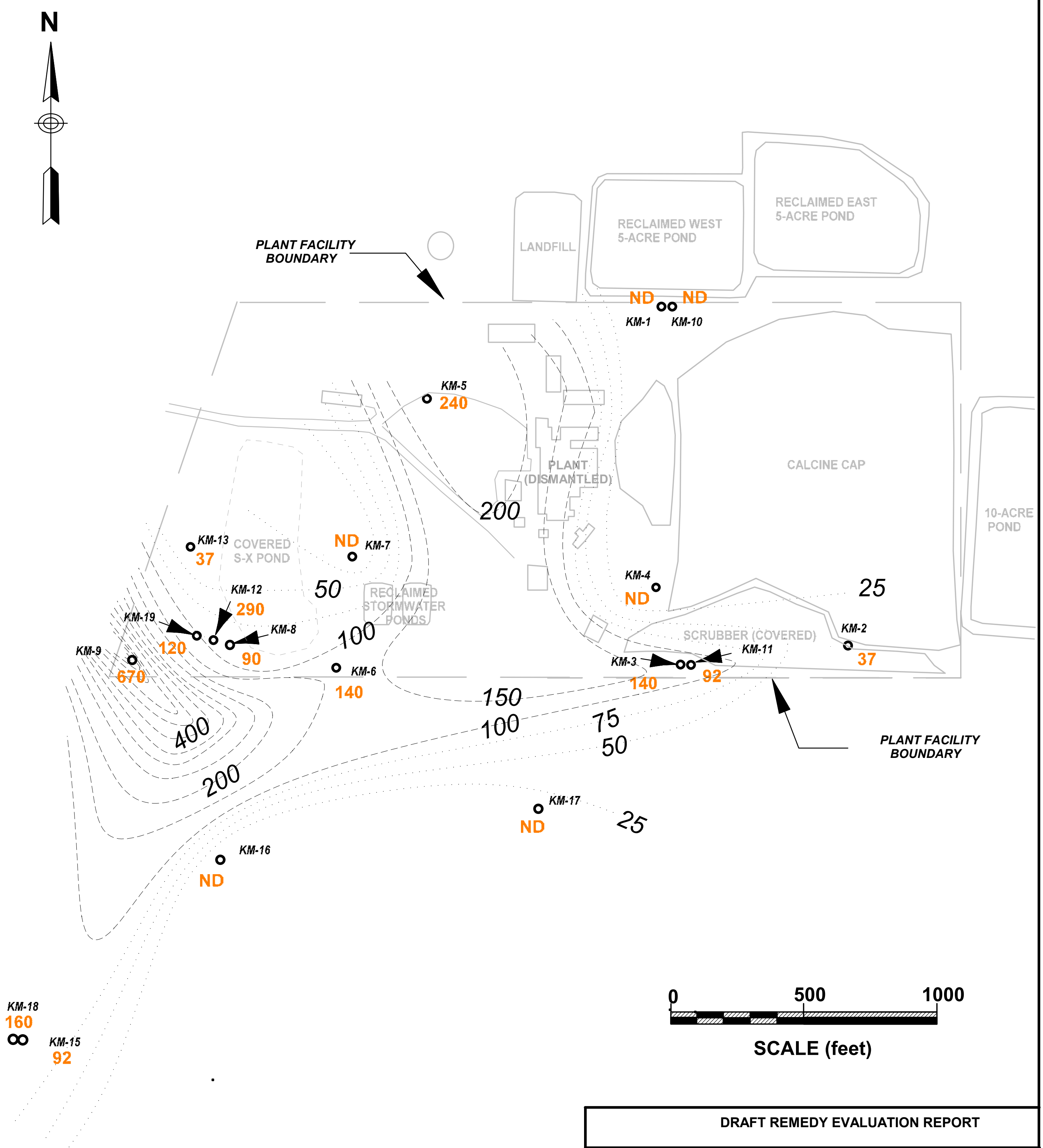
NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS
IN SHALLOW AQUIFER.

DRAFT REMEDY EVALUATION REPORT

CONCENTRATIONS OF DISSOLVED MANGANESE IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

FIGURE 2-14



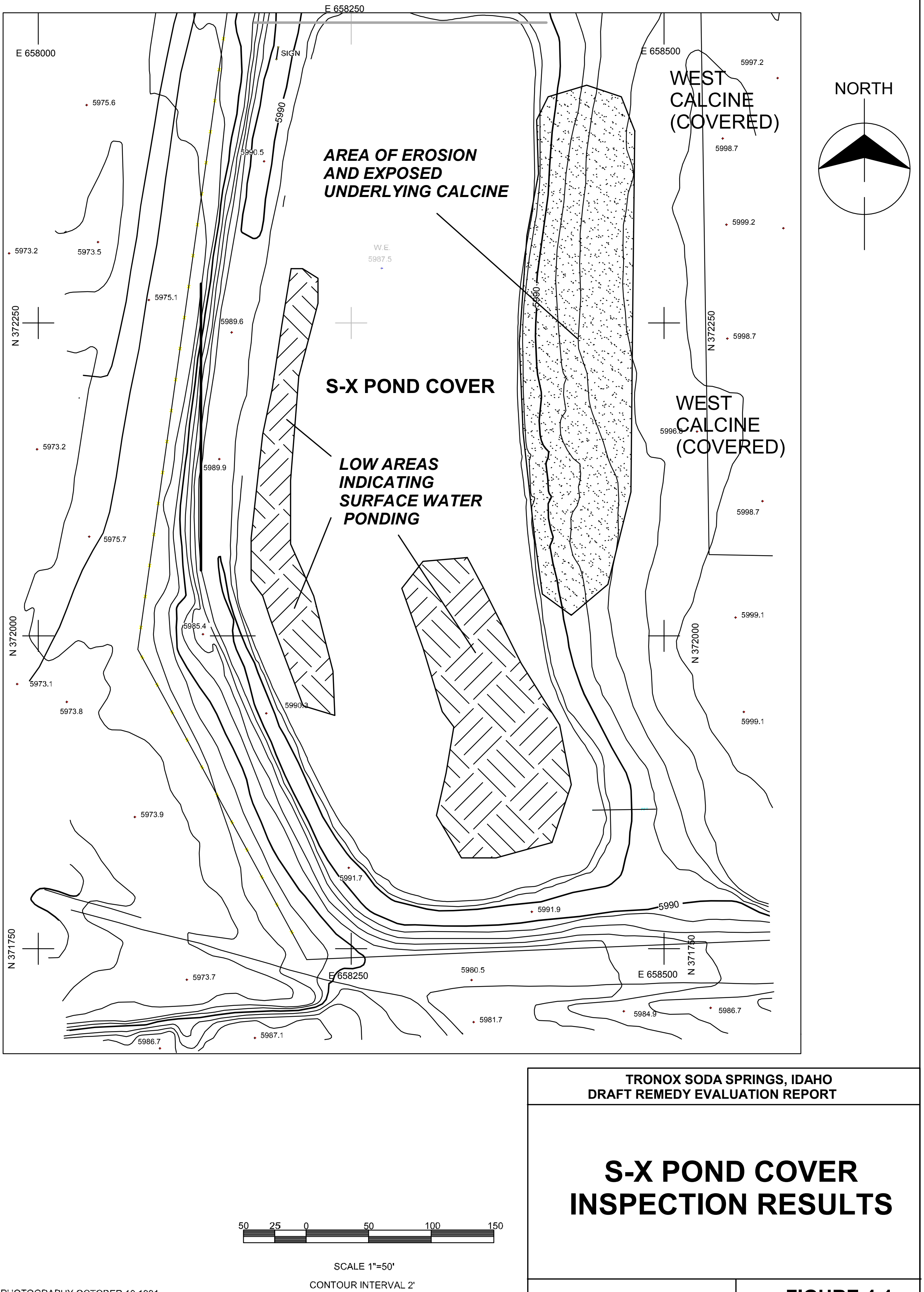
NOTE: CONCENTRATIONS ARE IN ug/l.
CONTOURS BASED ON CONCENTRATIONS IN SHALLOW AQUIFER.

DRAFT REMEDY EVALUATION REPORT

CONCENTRATIONS OF DISSOLVED IRON IN GROUND WATER OCTOBER 2008

TRONOX
SODA SPRINGS, IDAHO

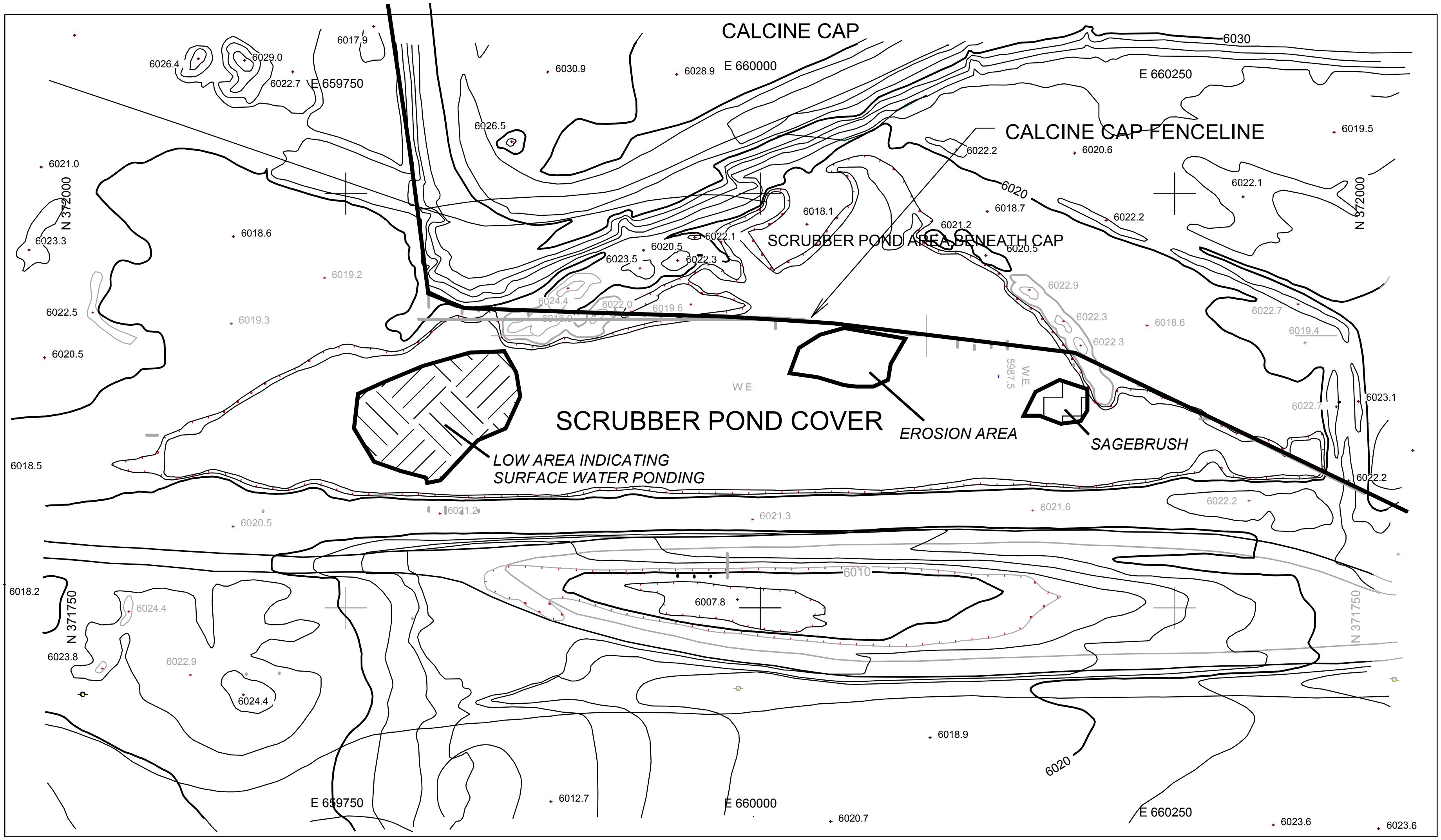
FIGURE 2-15



TRONOX SODA SPRINGS, IDAHO
DRAFT REMEDY EVALUATION REPORT

S-X POND COVER INSPECTION RESULTS

FIGURE 4-1



50 25 0 50 100 150

SCALE as shown

CONTOUR INTERVAL 2'

DATE OF PHOTOGRAPHY OCTOBER 10,1991

DRAWN BY J.S.BROWN P.G.

DATE: 2/14/09

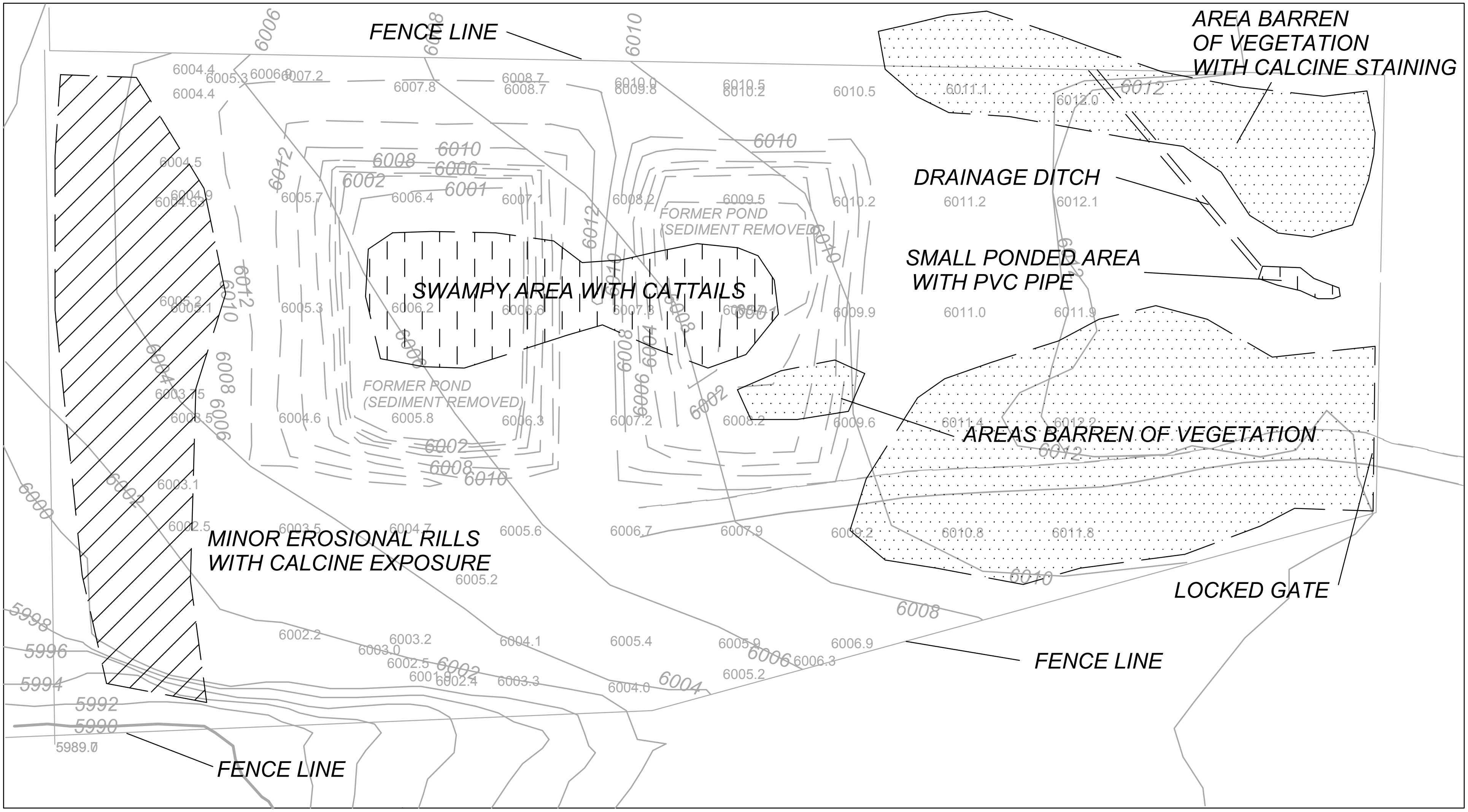
DRAFT REMEDY EVALUATION REPORT

TITLE

SCRUBBER POND COVER INSPECTION RESULTS

SIZE	CAGE CODE	DWG NO	REV
A			1

SCALE		SHEET	FIGURE 4-2



50 25 0 50 100 150

REMEDIAL INVESTIGATION REPORT, DAMES & MOORE, 1995

DRAWN BY J.S.BROWN P.G.

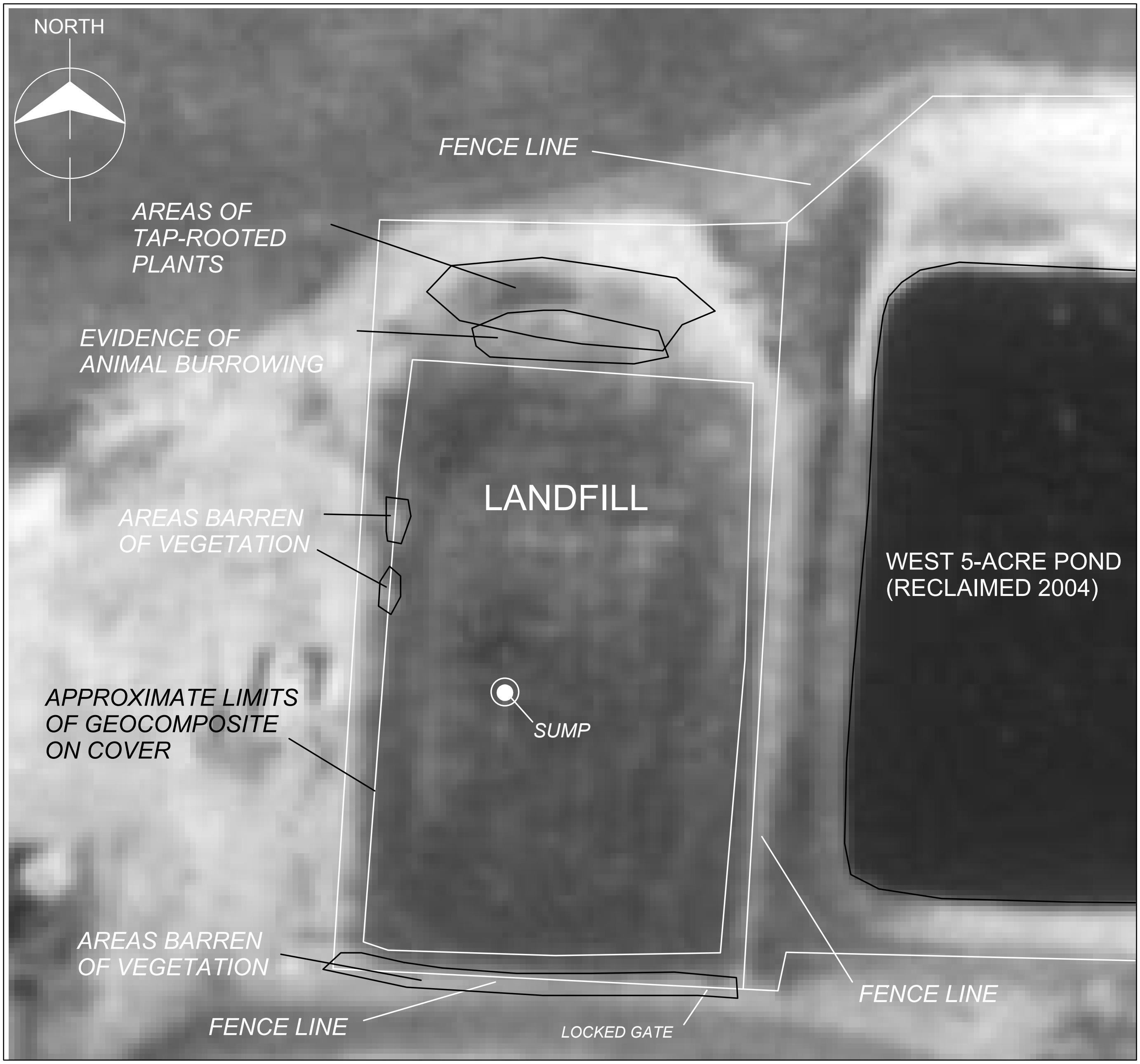
DATE: 2/16/09

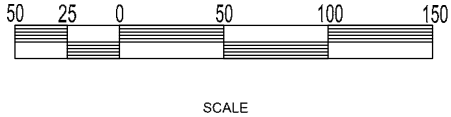
DRAFT REMEDY EVALUATION REPORT

TITLE

LIMESTONE SETTLING PONDS INSPECTION RESULTS

SIZE	CAGE CODE	DWG NO	REV
A			1
SCALE		SHEET	**FIGURE 4-3**



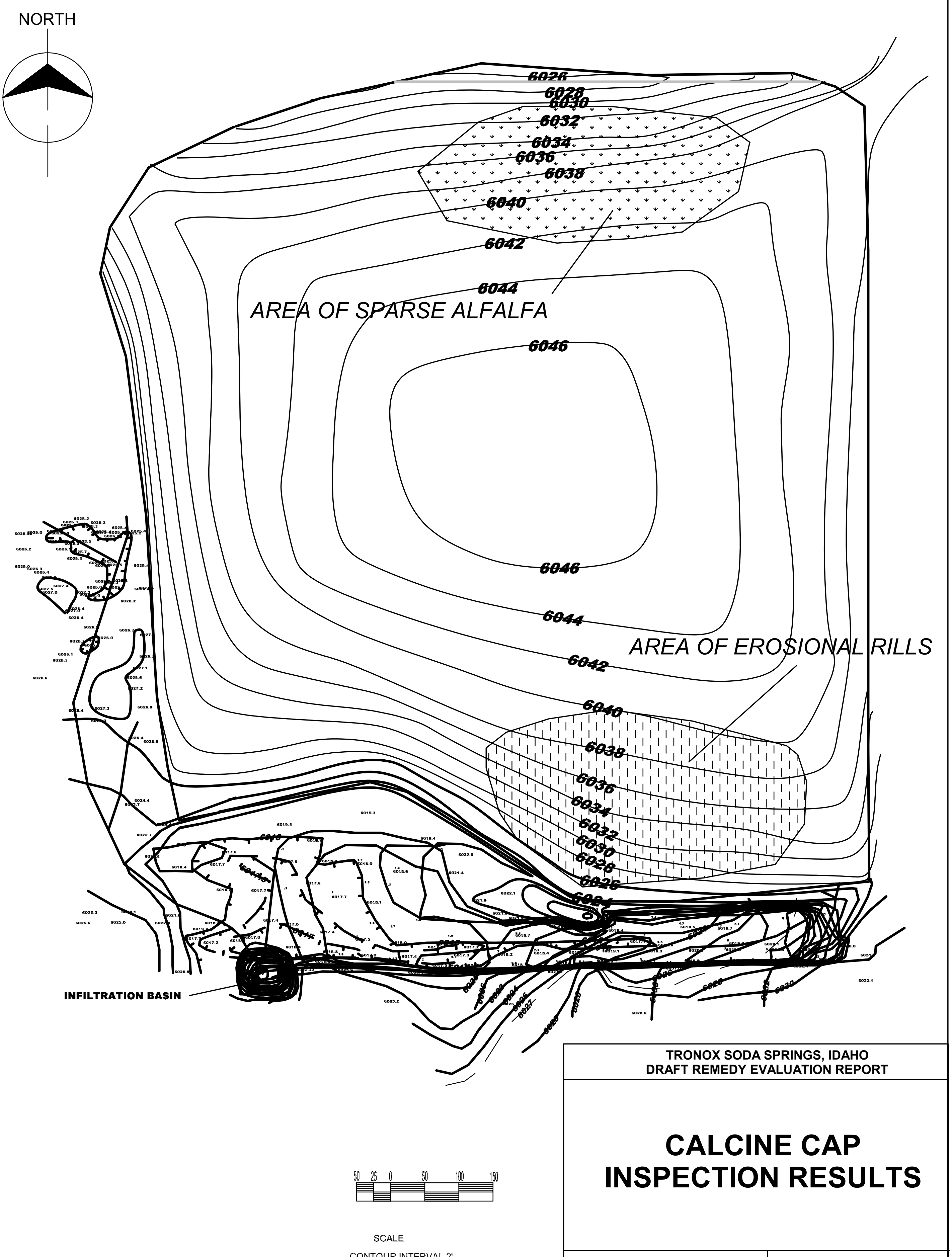


DATE OF PHOTOGRAPHY SEPTEMBER 7, 2000

DRAFT REMEDY EVALUATION REPORT

ON-SITE LANDFILL INSPECTION RESULTS

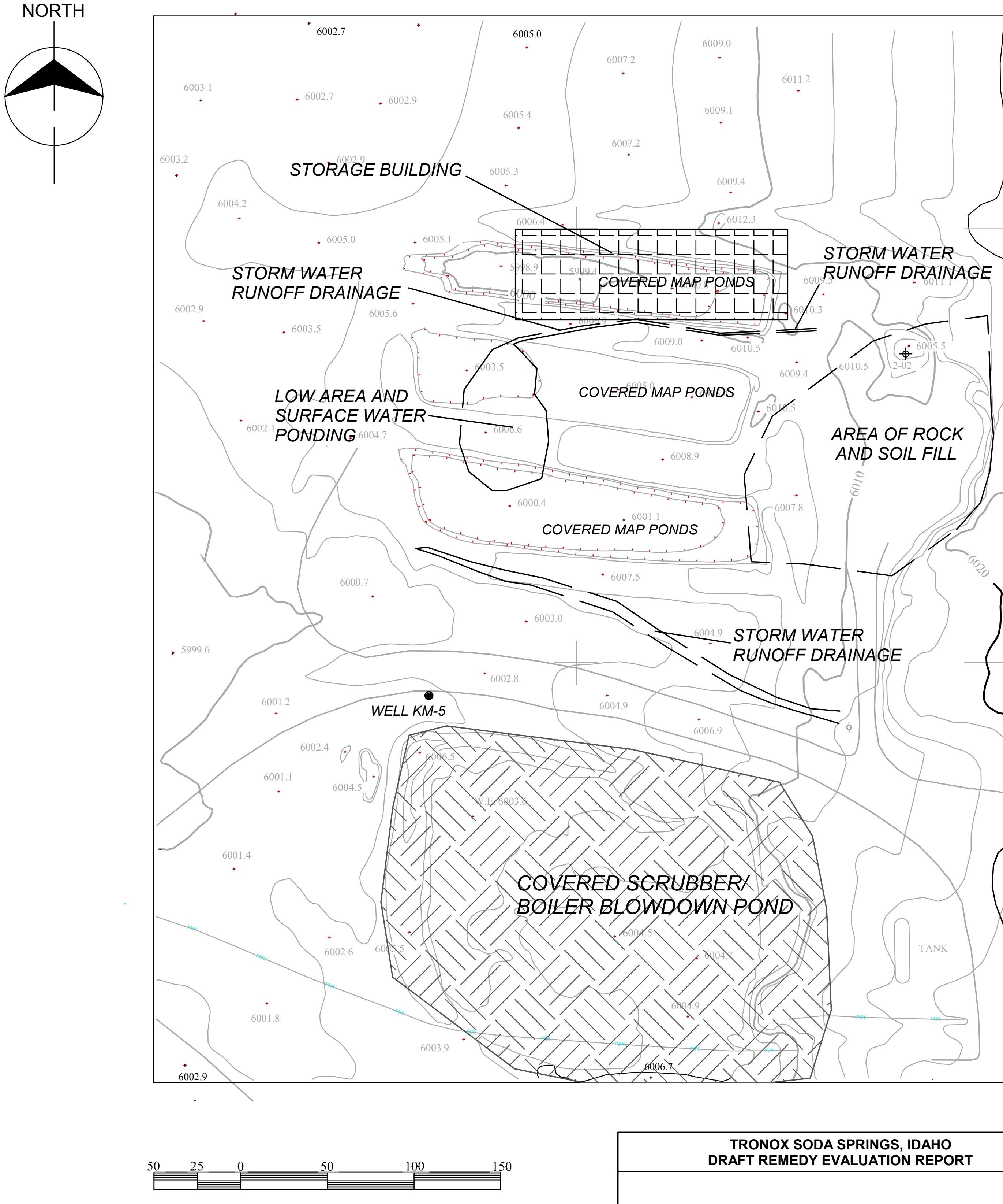
FIGURE 4-4



TRONOX SODA SPRINGS, IDAHO
DRAFT REMEDY EVALUATION REPORT

CALCINE CAP INSPECTION RESULTS

FIGURE 4-5



SCALE

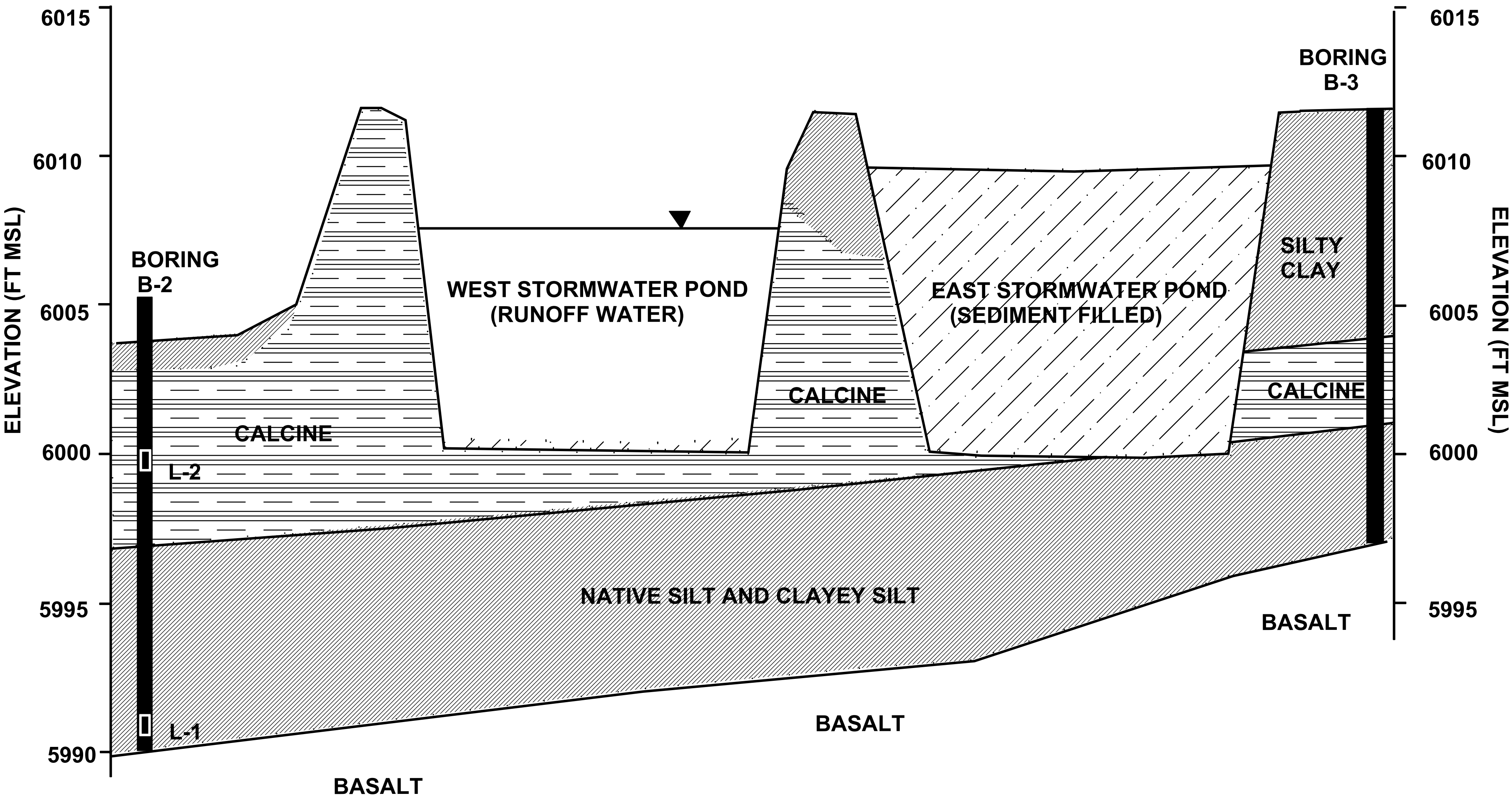
CONTOUR INTERVAL 2'

DATE OF PHOTOGRAPHY OCTOBER 10,1991

TRONOX SODA SPRINGS, IDAHO
DRAFT REMEDY EVALUATION REPORT

MAP PONDS INSPECTION RESULTS

FIGURE 4-6



NOTE: VERTICAL EXAGGERATION 8:1

DRAFT REMEDY EVALUATION REPORT

TITLE

CROSS SECTION OF STORM WATER PONDS LOOKING NORTH

SIZE	CAGE CODE	DWG NO	REV
A			0

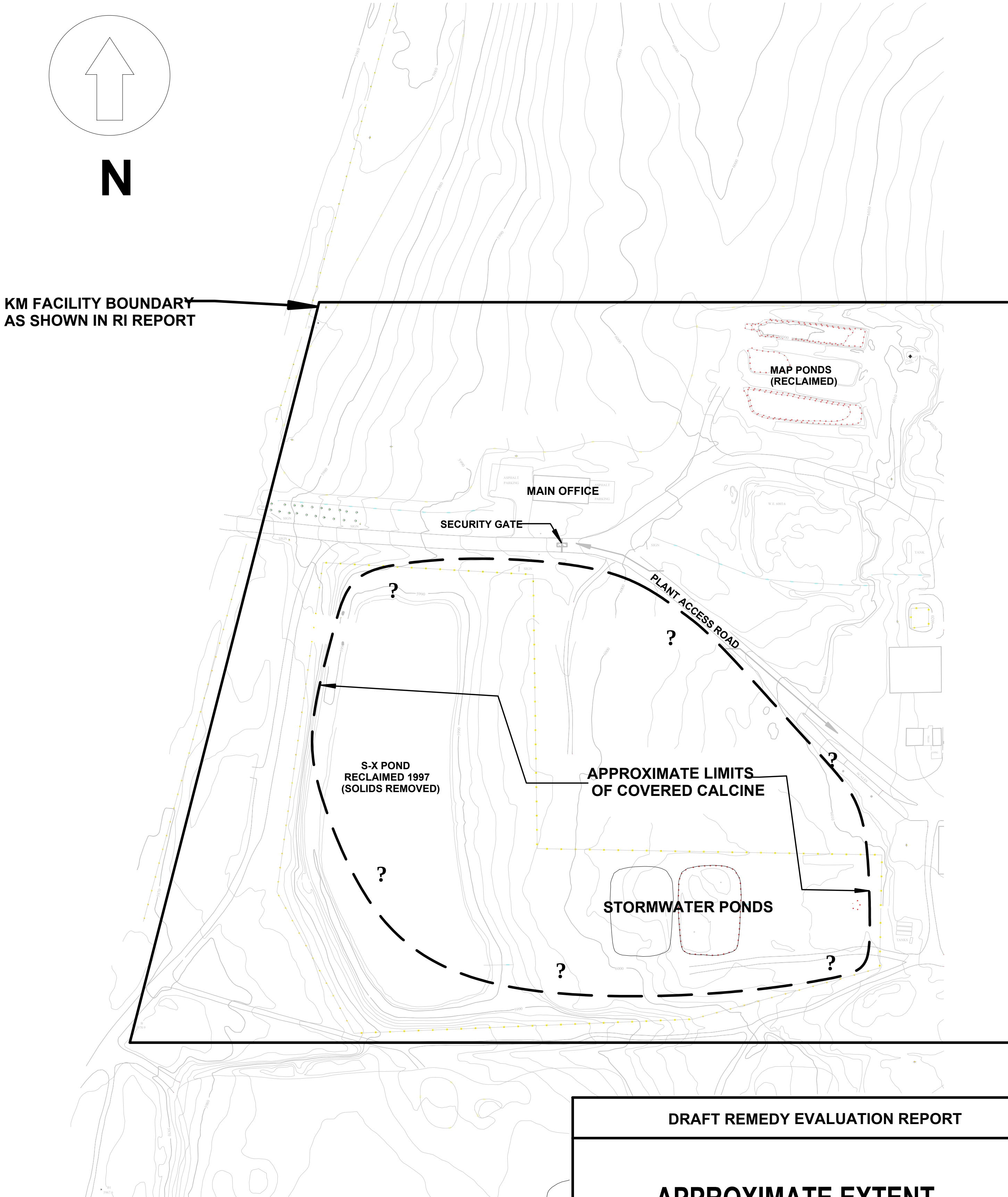
DATE: 2/14/09

SCALE

DRAWN BY J.S.BROWN

SHEET

FIGURE 4-7



DATE OF PHOTOGRAPHY OCTOBER 10,1991

50 25 0 50 100 150

SCALE (feet)

DRAFT REMEDY EVALUATION REPORT

APPROXIMATE EXTENT OF COVERED CALCINE

Tronox
SODA SPRINGS, IDAHO

FIGURE 4-8